



4TH GRADE CURRICULUM

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Ending project: Testing and Building Solar Ovens

Lesson 1: 4th Grade

What is Energy?

- Brainstorming activities to begin discussion
- Discussing 4 forms of energy: mechanical, thermal, electrical, chemical
- Experiments exploring energy conversion (ex. running in place—mechanical energy into thermal energy)

Lesson 2: 4th Grade

What is Potential Energy?

- Create Energy Matrix Conversion Charts
- Candle burning experiment—discuss potential energy

Lesson 3: 4th Grade

Embodied Energy & Energy Fuel Sources

- Discuss renewable and non-renewable fuel sources
- Fueling our bodies
- Energy Stories Puzzle Pack exercise: different energy sources (natural gas, electricity, wood, solar)

Lesson 4: 4th Grade

Radiant Energy

Solar Energy: A Renewable Energy Source

- Discuss the solar system and the sun as an energy source
- Exercises about absorption and reflection
- Introduce solar ovens: a brief history, different styles, where and why are they used

Lesson 5: 4th Grade

Maria Telkes: Mini-book

- 10 lesson mini history exercise about Maria Telkes and the history of solar cooking

Lesson 6: 4th Grade

Cooking Internationally with Solar Ovens

3 Solar Oven Projects

- Kenya: building solar ovens with Kenyan communities
- India: a government sponsored program
- Haiti: local volunteers work in Haiti building solar ovens and teaching classes

Lesson 7: 4th Grade

Solar Oven Experiments

- Measuring inside temperature of solar ovens with IR thermometers
- Heat water using a solar ovens
- Graph and chart data

Lesson 8: 4th Grade

Building Solar Ovens

- Working in small groups, build 2 different Minimal Solar Cookers

Lesson 9: 4th Grade

Building Solar Ovens

- Continue building the Minimal Solar Cookers

Lesson 10: 4th Grade

Cooking with the Solar Ovens

- Cook different foods (beans, rice, bread, stews) in the solar ovens

Lesson I: 4th grade

What is Energy?

Lesson Overview: All life and action in the world involves some form of energy.
Lesson Concept: Any physical process that takes place in the world involves mechanical energy.

Materials:

- Large white paper for note-taking
- 4 different colors of construction paper or poster board
- Hand bell (to ring)
- Wooden unit blocks or other large blocks to set up as “dominoes”
- Large plastic tub
- Water toys
- Black marker
- Dynamo flashlight
- Hotplate
- Tea Kettle with functioning whistle

Standards:

- **English:**
 - **IX.11.LE.1** (Inquiry & Research: Generate questions about important issues that affect them or topics about which they are curious, and use discussion to narrow questions for research).
- **Mathematics:**
 - **III.1.LE.4** (Data Analysis & Statistics: Identify what data are needed to answer a particular question or solve a given problem, and design and implement strategies to obtain, organize and present those data).
- **Science:**
 - **IV.1.LE.4** (Use Scientific Knowledge from the Physical Sciences in Real-World Contexts: Identify forms of energy associated with common phenomena).

Timeline: 1 class period (40 – 50 minutes)

Class Structure: whole class experiments and discussion

Assessment Strategy: EEK! Daily Assessment
General Assessment Strategy #1

Lesson I: 4th grade

What is Energy?

This lesson is an introduction and exploration of what is energy. This lesson focuses on physical movement—student’s moving their bodies and moving objects with their bodies—as one way of beginning to think about energy.

Lesson Overview: All life and action in the world involves some form of energy.

Lesson Concept: Any physical process that takes place in the world involves mechanical energy.

Supplies Needed:

- Large white paper for note-taking
- 4 different colors of construction paper or poster board
- Hand bell (to ring)
- Wooden unit blocks or other large blocks to set up as “dominoes”
- Large plastic tub
- Water toys
- Black marker
- Dynamo flashlight
- Hotplate
- Tea Kettle with functioning whistle

Background Information:

The primary focus is on mechanical energy / our bodies in motion. Often, physical movement is a good starting point for introducing larger—more complex—issues. During this lesson, the focus is for students to realize that ‘energy’ is an integral part of their life—they cannot live and move without ‘energy’.

Mechanical energy can be understood as the moving of any mass through space (air). This basically includes any physical actions that take place in the world. Therefore, using our bodies as examples to demonstrate mechanical energy is a good starting place. But, please do not stress that our bodies are machines. Mechanical does not mean mechanistic. We are much more than machines, even in the world of physics.

CLASS EXERCISES:

I. Brainstorming ‘What is Energy?’ with the class

Begin the class by asking the question: what do you think energy is?

Write down all the responses on a large piece of paper (we suggest 18 x 24 heavy duty construction paper or poster board) that you can keep posted in the classroom or hang up during the subsequent lessons for reference.

Prompts:

- Does your body use energy? When?
- Where does your energy come from?
- How do plants grow? What do they need in order to grow and be healthy?
- How do animals (other than humans) grow? What do they need in order to grow and be healthy?
- How does your body grow? What do you need in order to grow and be healthy?

II. Forms of Energy

Write the following 4 different forms of energy on 18x24 pieces of construction paper or poster board (use different colors for each form of energy) and place on the board or wall where the class can see them.

4 Forms of Energy:

Mechanical energy

Thermal energy

Chemical energy

Electrical energy

Have the students brainstorm different examples of each form of energy. Write all their answers on white paper and place on the boards.

III. Hands-on Experiments

Conduct the following experiments. At this point, we are not introducing energy conversion but just the final form of energy (the end result) in each experiment. Explain that the energy of motion is mechanical energy.

Ask the students what could be happening to make the following experiments occur, encourage short *and* elaborate responses:

After each experiment, have the students brainstorm (and then write down their ideas) which form of energy is represented in each experiment.

4 Forms of Energy:

Mechanical energy

Thermal energy

Chemical energy

Electrical energy

A. Have the students discuss what form of energy is represented in the following experiments:

1. Listening to sounds: sound energy is mechanical energy. The following explanation is a simplification of the process of hearing sound: Sound waves (vibrations) move through the air, reach the ear, then vibrate the inner ear (this is where sound amplification takes place), and we hear sound.
 - a. Hands clapping
 - b. Ringing a bell
2. Turning on the light switch: electrical energy
3. Moving their bodies: mechanical energy
 - a. Jumping in place
 - b. Rubbing hands together
4. Domino effect: mechanical energy
 - a. Set up a row of large unit blocks and demonstrate chain reaction by pushing them over

***Teacher's Note:** It is very important to use the scientifically accepted language from the very beginning of introducing a concept. Hence, not saying "sound energy", but instead "sound

energy is actually mechanical energy because we are moving air with vibrations—we hear these vibrations as sounds.”

IV. Energy Conversions

Now, we take the lesson further by discussing **energy conversions**.

CLASS EXERCISE:

A. Have the students create the following experiments:

1. Rubbing Hands Together—**mechanical** into **thermal**
Rubbing your hands together creates friction. Whenever two ‘things’ create friction, heat is created.
2. Running in Place—**mechanical** into **thermal**
You run (mechanical) and your body begins to increase in temperature (thermal) and create body heat
3. Dynamo Flashlight—**mechanical** into **electrical**
Pumping your hand on the handle (mechanical) moves gears inside the flashlight (mechanical to mechanical) the gears spark an electrical current (mechanical into electric) and the light turns on as long as you continue to pump the handle.
4. Heating Water on a Hot Plate—**electrical** into **thermal**
The hot plate uses electricity (electrical energy). As the water molecules are excited (mechanical energy) the water becomes hot (thermal energy).
5. Boiling Water in a Kettle—**thermal** into **mechanical**
The boiling water (thermal energy) forces steam (chemical energy) through the whistle on the kettle and produces a sound (mechanical energy).

V. Stating results:

After completing the experiments use large sheets of paper to create a class Energy Conversion Matrix Chart. Below is an example of what one could look like to explain the energy conversions in the above experiments.

Energy Conversion Chart

From → To ↓	Mechanical energy	Thermal energy	Chemical energy	Electrical energy
Mechanical energy		Tea kettle whistling		
Thermal energy	Friction: rubbing hands together Running in place			Heating water
Chemical energy		Boil water		
Electrical energy	Dynamo flashlight			

LESSON WRAP-UP

- Ask students to try and explain energy conversion in their own words. One way to explore this is to ask the students to explain what happened in Class Exercise #1–rubbing your hands together. (We begin with our hands at rest, then put them in motion, and then create heat.)
- One way to explain energy conversion is: “We begin with an action. But, during that action a change takes place and our end result is that we now have something different—something that we didn’t begin with.”
- Another way to think of the overall concept for yourself is: There is a **potential to create energy and a result of creating energy** (potential energy is discussed later in the module for the students).

Lesson 2: 4th grade

Potential Energy

Lesson Overview: All ‘things’ in the world have potential energy.

Lesson Concept: Everything has potential energy but there are many possibilities for how the potential energy is converted into useable energy.

Materials:

- Dynamo flashlight
- 1 Pillar Candle
- Matches
- 1 large glass jar (mayonnaise size)

Standards:

- **English:**
 - **IX.11.LE.1** (Inquiry & Research: Generate questions about important issues that affect them or topics about which they are curious, and use discussion to narrow questions for further exploration).
- **Science:**
 - **I.1.LE.1** (Construct New Scientific and Personal Knowledge: Generate reasonable questions about the world based on observation).

Timeline: 1 class period (45 – 50 minutes)

Class Structure: whole class discussion with teacher led experiment

Assessment Strategy: EEK! Daily Assessment
General Assessment Strategy #1
General Assessment Strategy #2

Lesson 2: 4th grade

Potential Energy

This lesson introduces the concept of ‘potential energy’. This concept builds on the previous understanding of energy and energy conversion. This day will involve more hands-on demonstrations: revisiting experiments from Lessons 1 or 2 and introducing new ones.

Lesson Overview: All ‘things’ in the world have potential energy.

Lesson Concept: Everything has potential energy but there are many possibilities for how the potential energy is converted into useable energy.

Supplies Needed:

- Dynamo flashlight
- 1 Pillar Candle
- Matches
- 1 large glass jar (mayonnaise size)

Background Information:

Everything in the world has potential energy that can be converted into useable forms of energy. Your body, for example, has potential energy. It can move objects, squeeze flashlight handles, jump in the air. Here is another way to think about potential energy: food has potential energy stored inside of it. We eat the food and are able to run, jump, and think. The sun has potential energy and it can heat objects that absorb its energy.

REVIEW:

I. Dynamo Flashlights

Remember the Dynamo Flashlights? (Demonstrate the Dynamo and pass around the class).

- Discuss how the Dynamo flashlight works and the energy conversions involved in order to create the light. Ask the following questions:
 - What action causes the light to turn on? (Squeezing the handle with your hand causes the light to come on).
 - Do you remember the energy conversion that takes place? (At this point, you could hang up the colored pieces of paper from Lesson 2 that illustrated the sequence of the energy conversion.)
 - Energy conversion sequence: the motion of your hand squeezing the handle back and forth (**mechanical** energy to **mechanical** energy) turned gears inside the flashlight (**mechanical** energy to **mechanical** energy) that sparked wires (**mechanical** energy to **electrical** energy) and caused the light to come on (**electrical** energy to **electrical** energy). The mechanical energy was ultimately transformed into electrical energy.
 - Question: In the Dynamo flashlight experiment, what 2 things have potential energy? (your body and the Dynamo flashlight)

CLASS EXERCISE:

After discussing the above ideas about potential energy lead the Candle Burning Experiment. Refer to the Energy Conversion Matrix the class created during Lesson 2.

I. Candle Burning Experiment: this is a teacher-only led experiment

Have the students gather around a table and place the candle on the table.

(Supplies: 1 large pillar candle
Matches
Large glass jar (mayonnaise size))

The Main Concept of this experiment is to demonstrate a potential energy source

- Place the candle on the table
- Play a version of “Simon Says” with the students. Ask the students to take turns around the circle and direct you through the process of lighting the candle. If they miss a step, you will stop, make some sort of funny sound, and the next person has a turn.

Candle Lighting Steps: students take turns directing you (example of possible answer scenario below):

- Pick up the box of matches
- Open the box of matches
- Take a match out of the box
- Strike the match on the box
- Move the match over next to the wick
- Light the wick
- Blow out the match
- Put the extinguished match down in a safe place
- Close the box of matches

Now, the candle is lit. Have the students go through the same process out loud to figure out how the candle is staying lit.

Possible prompt questions for the students below: questions in green and responses in blue

- What happens to the candle as it burns?

The wax melts and forms a puddle at the base of the wick.

- What is the wick doing?

The wick is fueling the flame. The wick wicks up the wax from the melted puddle. The wick, through wicking up the wax, keeps the combustion reaction happening.

- How does the wick stay lit?

The wick stays lit because it is coated in wax.

- What happens if we cover the candle with glass jar?

The flame will die out. It needs the oxygen from the air to keep lit (keep burning, continue the combustion process).

- Why doesn't the entire candle melt instantaneously?

When something burns a combustion reaction occurs. The candle burning is a combustion reaction. Combustion reaction occurs depending on the amount of the fuel source and the amount of available oxygen in the air. The fuel source is the melted wax puddle created at the base of the wick. When we place the glass jar over the flame, we limit how much oxygen is available to "feed the flame". ****TEACHER NOTE: Rate limiting effect of combustion is how much oxygen is available to continue the combustion effect. ****

- What is the potential energy?

The candle is the potential energy.

- What is the fuel source?

The melted wax is the fuel source. And, the wick keeps the fuel source available for use.

- Have the students describe the change in energy (the energy conversion) that takes place during the Candle Burning Experiment. If they seem stumped, refer to the Energy Matrix Chart that has been created during Lessons 1 & Lesson 2.

Energy Conversion for Candle Burning Experiment

Chemical Energy to Thermal Energy:

The motion of your hand striking the match: mechanical energy

The match lighting: chemical energy

The candle burning: chemical energy

The candle creates heat: thermal energy

II. After finishing the Candle Burning Experiment, have the students re-cap 'what is potential energy' through the following actions. Also, have them map the energy conversions first and then ask what is the energy potential source.

- Jump in the air

Mechanical energy to mechanical energy: legs bend (mechanical energy) and jump into the air, your body pushes through the air around itself (mechanical energy) and then lands on the floor and makes a sound (mechanical energy). Potential energy: your body

- Run in place for 1 minute

Mechanical energy to thermal energy: legs move back and forth (mechanical energy), as your body is moving it begins to heat (thermal energy). Potential energy: your body

Lesson 3: 4th grade

Embodied Energy and Energy Fuel Sources

Lesson Overview: We use energy resources everyday.

Lesson Concept: There are many different energy sources used to create heat.

Supplies Needed:

- Energy Stories Student Packets
 - Illustrator: Jessica Western & Matt Issacson
- Large white construction paper
- Markers / pencils
- Student hand-outs (or use as teacher overheads)
 - Potential Energy & Energy Conversion Table

Standards:

- **Science:**
 - **II.1.LE.4** (Reflect on the Nature, Adequacy, and Connections Across Scientific Knowledge: Develop an awareness of and sensitivity to the natural world).
 - **IV.1.LE.4** (Use Scientific Knowledge from the Physical Sciences in Real-World Contexts: Identify forms of energy associated with common phenomena).
 - **V.1.EE.5** (Use Scientific Knowledge from the Earth and Space Sciences in Real-World Contexts: Describe uses of materials taken from the earth).
- **Social Studies:**
 - **II.2.EE.1** (Geographic Perspective: Describe how people use the environment to meet human needs and wants).
 - **II.2.EE.2** Geographic Perspective: Describe the ways in which their environment has been changed by people, and the ways their lives are affected by the environment).

Timeline: 1 class period (45 – 50 minutes)

Class Structure: small group project

Assessment Strategy: EEK! Daily Assessment
Pre-Module Assessment Question #1

Lesson 3: 4th Grade

Embodied Energy and Energy Fuel Sources

In this lesson, students will learn about four main fuel sources.

Lesson Overview: We use energy resources everyday.

Lesson Concept: There are many different energy sources used to create heat.

Supplies Needed:

- Energy Stories Student Packets
 - Illustrator: Jessica Western & Matt Issacson
- Large white construction paper
- Markers / pencils
- Student hand-out (or use as teacher overhead)
 - Potential Energy & Energy Conversion Table

Background Information:

Potential energy, embodied energy, and different fuel sources will be the primary foci of this lesson. Through using cooking food as our linking example, different cooking methods will be explored as well as the embodied energy (potential energy) in energy sources. This background material on food will be the basis for Lessons 6-10 when we discuss different eating habits/customs around the world and how people throughout the world use different methods to cook food.

The main concepts of this lesson are:

- Introduce the idea that there are many different energy sources used to create heat
- Discuss different energy sources that are used throughout the world—not everyone in the world has a stove fueled by electricity or natural gas (as in the United States)—for cooking
 - Some of these energy sources are renewable and some are non-renewable

Renewable energy sources: Infinite supply

Non-renewable energy sources: Finite supply

CLASS EXERCISES:

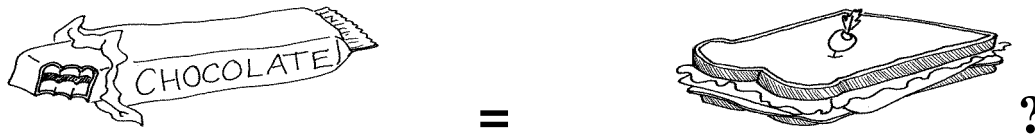
Recall the Candle Burning Experiment and the experiments we did afterward. Now, we have a basic idea of what is embodied energy and how we could identify potential energy. Also, we have compiled a chart of energy conversions over the last (few days, few lessons, etc.). (Have the Energy Conversion Matrix up in a visible place for this lesson). Let's now focus on our bodies.

I. Food and Energy

Lead Questions:

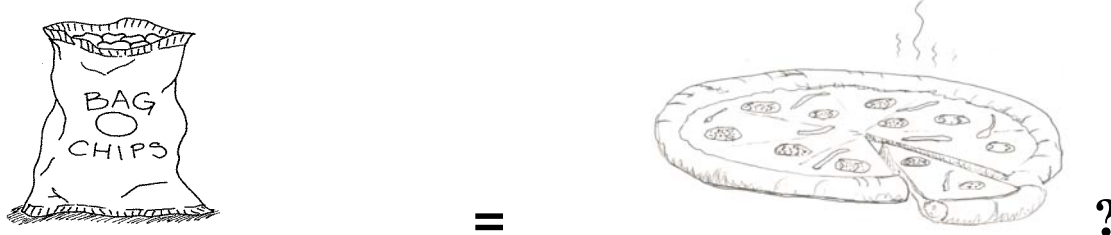
- How does your body get its energy?

- Do you get the same amount of energy from all foods, no matter what food you eat? For example, do you get the same amount of energy—amount and time—from eating a bag of chips and a cheese sandwich?
- Which would you get more energy from? (More = longer and stronger) for example, if you were going to run around the track 10 times, what might you eat if you wanted a long and sustained amount of energy?
- What might you eat if you wanted a short “burst” of energy?
 - A candy bar or a sandwich?



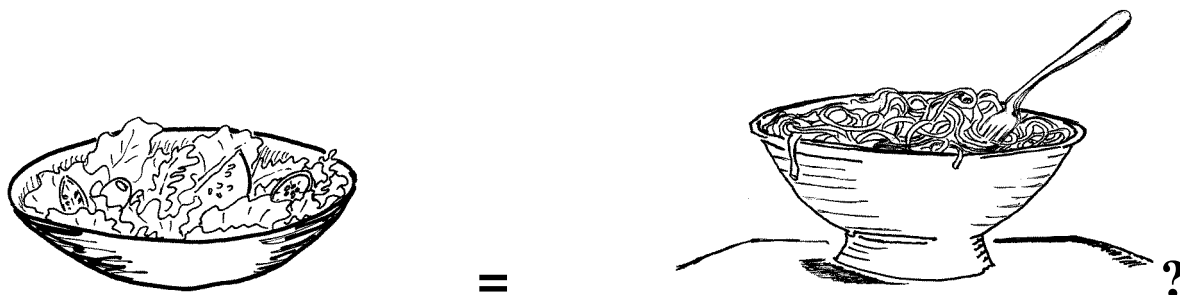
illustrators: Jessica Western and Matt Isaacson

- A piece of pizza or a bag of chips?



illustrators: Jessica Western and Matt Isaacson

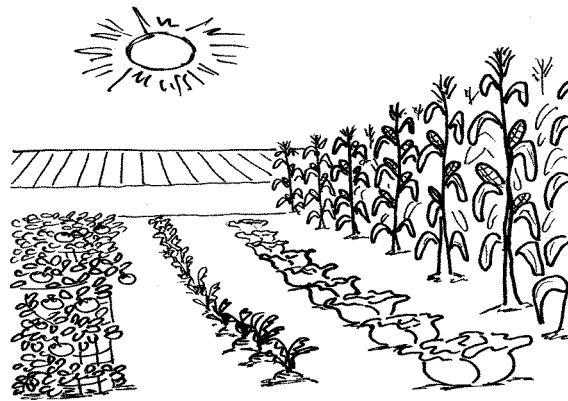
- A salad or a bowl of pasta?



illustrators: Jessica Western and Matt Isaacson

Your body needs fuel to keep it alive and moving and different foods have different amounts of embodied energy in them that your body converts into useable energy through the chemical process of digestion. There is a finite amount of stored potential energy within food.

Teacher's Note: In the above examples, we are not discussing strict calorie content. The idea to stress with the students is which food would provide you with a longer sustained amount of energy (i.e. which food should you eat to accomplish the most amount of work over the longest period of time).



II. Cooking Food

Lead Questions:

- How do you cook food at your home? (gas stove, electric stove, microwave oven, toaster oven)
- How might people in other countries cook their food or heat water if they don't have access to electricity? (propane, wood, charcoal, dung)

III. Energy Stories: diagramming energy sources: a Discovery Lesson

The students will create diagram stories based on the following text and images to describe the process of using different energy sources for fuel. Encourage the students to BE CREATIVE! and create their own fuel source diagram. This exercise can be done alone or in groups.

- Hand out the Energy Stories Picture Packs (1 to each group)
- Have the student groups arrange the pictures to create an Energy Story
- Let the students arrange the stories how they think describes the process
- Not all the pieces of the puzzle are given in the picture packs. The students will need to “fill in the gaps” of the story to have it make sense. Make sure they know this when you hand out the picture packs.
- After the students arrange the picture pieces and draw in the missing pieces, have them write a description on the top of each picture to tell the story in words also.
- The class will be working on all 4 examples simultaneously. Use the following 4 examples of fuel methods for the remaining lesson: **natural gas**, **electricity**, **wood**, **solar**
- Gas Stove cooking: **natural gas** is the potential energy source
- Electric Stove cooking: there are many options for the **potential energy source**--- water (hydroelectric), coal, natural gas, windmill, oil fired burner, wood burner.

Usually, from the electric company, there is a combination of sources being used to supply the electric company grid with power.

- Wood for Fuel cooking: **wood** is the potential energy source
- Solar cooking: the **sun** is the potential energy source (they might not suggest this idea, if they don't introduce the idea AFTER going through the diagrams and info for gas, electric, and wood cooking.
- After the class completes their Energy Story Diagrams, have the students share their stories with the rest of the class.
- Then, 'read' the Energy Story Placard Books (this is a book or sheet of paper you have created by gluing the Story Packs in consecutive order) for each energy fuel source and discuss the students' ideas with how energy is actually mined, moved, and converted into useable fuel sources.
- At the end of discussing each energy source, ask the students what is the potential energy source and if they can guess the energy conversion.

Teacher's Note: Detailed support materials are provided for electricity generation (sources and techniques) in the Background Information for this section. But, for this lesson, we chose to illustrate generating electricity through coal-fired plants. Coal is responsible for providing 25% of the world's energy.

LEAD QUESTIONS: Use the following lead questions to help the students along: but it is important for the students to arrange the pictures in the way they think is true with no further outside info---this is a discovery lesson.

Lead Questions: **Natural Gas**

- Does anyone have a stove that uses a flame?—That flame is natural gas.
- Natural gas is found deep inside the earth and then ends up as the flame in our stoves.
- How do you think natural gas gets out of the earth?
- Can you imagine a way the natural gas is moved from deep inside the earth to out of the earth?
- How might it be moved from one place to another?
- How does the natural gas get to your stove? (hint: you don't buy it with your stove)
- What kinds of equipment do you think might be used to get natural gas out of the earth?
- What kinds of equipment do you think might be used to move natural gas from one place to another?
- Do you think people help?
- If yes, how might people help?

Lead Questions: **Electricity**

- Does anyone have a stove that has electric coils that heat up? Or a toaster oven? —
—Electricity is making the stove and toaster oven work.

- Coal is a very common way to make electricity in the United States.
- Coal is found deep within the earth.
- What color do you think coal is?
- Do you think coal is heavy, light, hard, soft?
- How might coal be taken from out of the earth?
- How do you think coal is carried from deep inside the earth to out of the earth?
- How is coal moved from one place to another?
- How could coal make electricity? (hint: coal can be burned)
- Where is the electricity stored?
- How does electricity move from one place to another?
- How might electricity reach your stove or toaster oven inside your house?

Lead Questions: Wood

- Has anyone ever made a fire out of wood?
- Has anyone ever cooked food over a fire—on a grill, or over a campfire, or in a fireplace?
- People in many parts of the world use wood to cook their food.
- How might wood be moved from one place to another?
- How long do you think it takes for a tree to grow before it could be considered as “good firewood”?
- If your family depended on wood to cook your food, what would you do if all the trees were cut down near your home?
- What happens when you burn wood? (hint: smoke can get in your eyes)
- How does it feel when smoke gets in your eyes or throat? (Many people become very sick with eye, and lung diseases where wood is used to cook food).

Lead Questions: Solar

- If you lie outside on a sunny day, how does your skin feel?
- What is making your skin hot?
- Have you ever tried to walk barefoot on the sidewalk on a sunny day? What happened?
- Do you think you could cook food with the sun?
- If you were making an oven to cook food with the sun, what would it look like?
- What would you make your oven out of?
- How would the sun heat your oven?
- What kinds of food might you cook in your oven heated by the sun?
- Where would you want to live if you cooked food with a sun oven? (hint: be specific—think of a few countries / states / bioregions or specific times of the year in your home bioregion).

IV. Renewable or Non-renewable Sources of Energy

From the above 4 examples, have the class decide which energy sources are renewable (sun, wood) and which are non-renewable (natural gas, electricity from coal). Make large charts to place next to the Energy Matrix Chart:

Renewable	Non-Renewable
Solar (the sun)	Natural gas (all fossil fuels)
Wood	Coal fired electric plants*

We are focusing for this lesson on electricity created from coal-fired plants. But, there are multiple ways that electricity is generated. Please see Teacher's Notes if you want to elaborate on this topic.

V. Introduce International Cooking Study

Ask the following questions to students after completing the Energy Story from section III.

1. Where might people live who use natural gas as their primary source of energy? (United States)
2. Where might people live who use electricity as their primary source of energy? (United States)
3. Where might people live who use wood as their primary source of energy? (Kenya, Haiti)
4. Where might people live who could use the sun as their primary source of energy? (Kenya, Haiti, India)

IV. Embodied Energy and Energy Conversions

Brainstorm the potential energy for each fuel source. I.e. What has the embodied energy that is then turned into useful energy?

LESSON WRAP-UP:

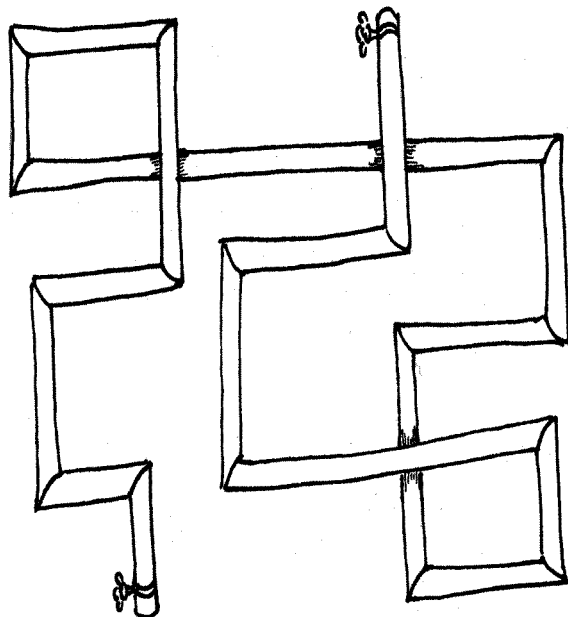
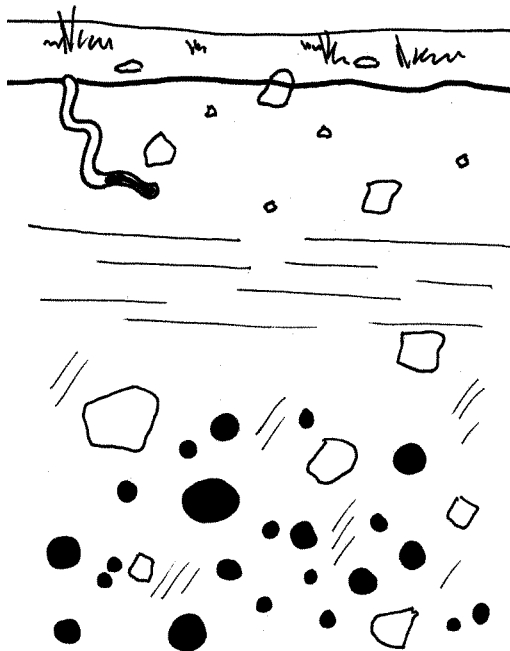
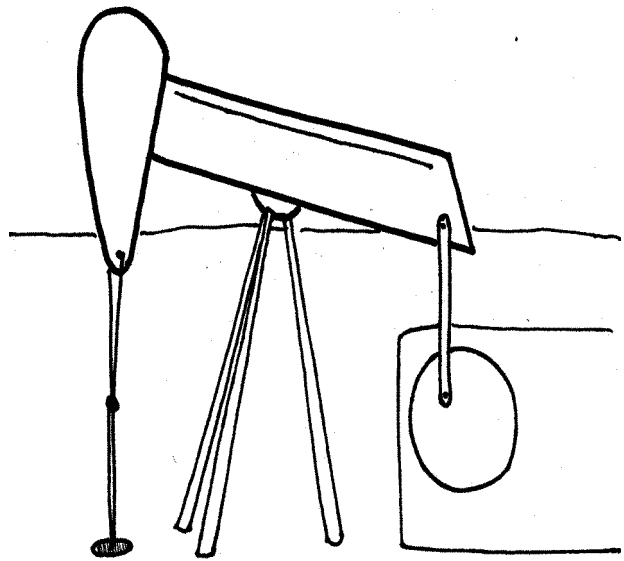
- As a class discussion or small group discussion, ask the students to map (create a chart) the energy conversions of each fuel source from the Energy Story Diagrams.
- Hand out the Potential Energy and Energy Conversion Table for Student for further information. We encourage this information to be given to students after they have created their Energy Story Diagrams.

Potential Energy and Energy Conversion Table for Students

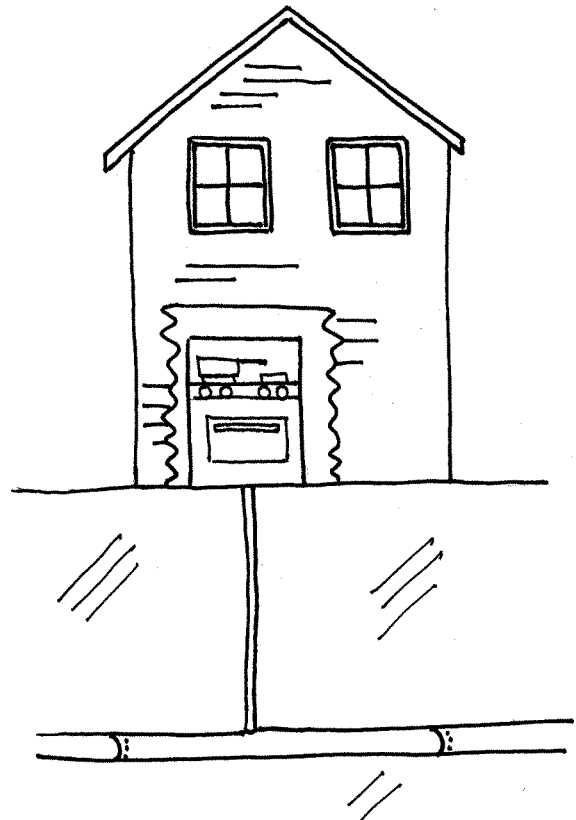
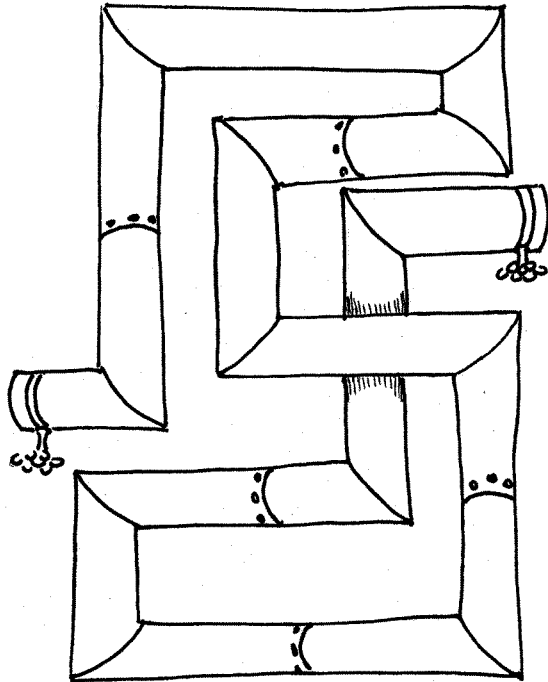
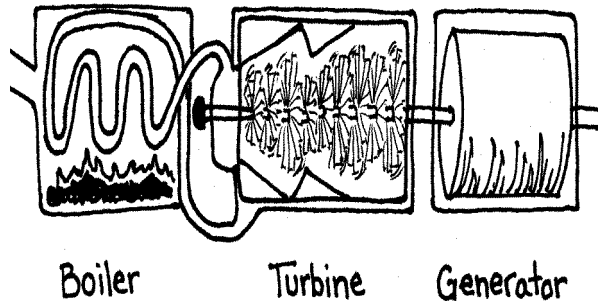
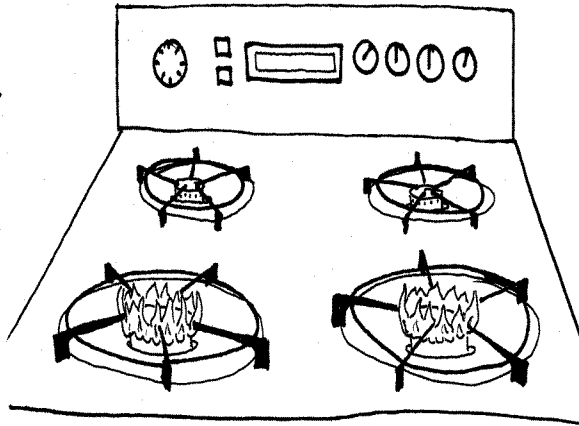
Potential Energy	Energy Conversion
<p>Natural gas</p> <p>Potential energy source: natural gas</p>	<p>Natural gas is a fossil fuel. It is a colorless, odorless* gas formed millions of years ago from tiny plants and animals. It is located in underground rock formations in sedimentary basins. Natural gas is primarily used to produce heat.</p> <p>Natural gas is a non-renewable source of energy.</p> <p>*Mercaptan, an odorant that smells like rotten eggs, is added to natural gas so leaks can be detected.* (The above information is from the NEED Project, p.10)</p> <p>Natural gas is mined from deep inside the earth, pumped out, and then shipped (up to millions of miles) through underground pipelines to the gas supply facility in your state. It is then distributed to a regional power supply company. In Michigan, one of the power companies is Consumers Energy.</p> <p>Natural gas pipelines are laid deep in the ground throughout your town and neighborhood. Some houses, but not all, have pipes connecting the larger pipes in your neighborhood to the smaller natural gas lines in your house. If you have a gas stove, the stove has gas lines connecting it to the larger gas lines in your house that are connected to the even larger gas lines in your neighborhood that are connected to the even larger gas line piping network throughout your town where those pipes are connected to the main supply area.</p> <p>Energy Conversion: chemical energy to thermal energy</p>
<p>Electricity—coal burning</p> <p>Potential energy source: coal</p>	<p>Coal is a black, solid fossil fuel formed from the remains of ancient plants in swamps millions of years ago. It is located underground in many areas of the United States. Wyoming, West Virginia, Kentucky, Pennsylvania, and Texas are the top coal-producing states. Shallow coal seams are surfaced mined and coal buried deep inside the earth is reached through underground mine shafts. Most coal is burned to produce heat.</p> <p>Coal is a non-renewable source of energy.</p> <p>Coal is used to produce more than half of the electricity in the United States. (The above information is from the NEED Project, p.8)</p> <p>Coal is mined from deep inside the earth, chiseled out, and carried to the surface. The coal is then shipped, primarily by railroad and barge, throughout the country to power plants. Since it is a very heavy, dense material, coal is expensive to transport.</p> <p>Burning coal (and oil) creates sulfur dioxide, nitrogen oxide, and carbon dioxide. These gases are the main contributors to creating acid rain, smog, and global warming. The mining technologies cause habitat destruction and loss, and pose severe health risks often leading to fatal disease (black lung disease of coal miners) for the workers.</p>

	<p>Energy Conversion: chemical energy to electrical energy to thermal energy</p>
<p>Wood</p> <p>Potential energy</p> <p>source: wood fibers</p>	<p>Different types of wood have different amounts of embodied energy. Dense, dry woods have the highest embodied energy. For example, seasoned oak has more embodied energy than pine. So, the type of wood that is being burned is very important.</p> <p>More than 2 billion people world-wide depend primarily on wood for their energy needs. And, in countries where wood has been traditionally relied on as the primary energy source, fuel wood is becoming scarce. Deforestation, leads to siltification of rivers, land erosion and soil nutrient depletion. This then in turn affects crop yields, drinking water quality and availability, species destruction and decline in species populations of plants and animals.</p> <p>In countries wood is the primary fuel source, the amount of time typically spent gathering wood is 3 hours every day. Scientists believe in countries where wood is burned to cook food, the pollution from burning wood increases eye and lung diseases in women and children.</p> <p>Even though wood is a renewable resource—new trees can be planted after others have been cut down—it is important to remember that it may take many generations for a tree to grow to maturity.</p> <p>Energy Conversion: chemical energy to thermal energy</p>
<p>Solar</p> <p>Potential energy</p> <p>source: the sun</p>	<p>Solar energy is radiant energy from the sun that travels to earth in electromagnetic waves (or rays).</p> <p>Solar energy is produced in the sun's core when atoms of hydrogen combine under pressure to produce helium, in a process called fusion. During fusion, radiant energy is emitted.</p> <p>Solar energy is harnessed with solar collectors that turn the radiant energy into heat. Photovoltaic cells turn radiant energy into electricity. We also use solar energy to see.</p> <p>The sun heats things on earth. Solar energy is only available when the sun is out. If it is a cloudy day or at night, there is no solar energy available.</p> <p>Special ovens are used around the world to focus the sun's heat and cook food. Using the sun to cook food and heat water is becoming more popular in many countries that once used wood.</p> <p>Solar energy is a very clean energy source, producing no air or water pollution. (The above information is from the NEED Project, p. 11)</p> <p>Energy Conversion: electromagnetic energy to thermal energy</p>

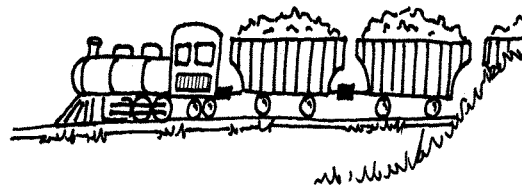
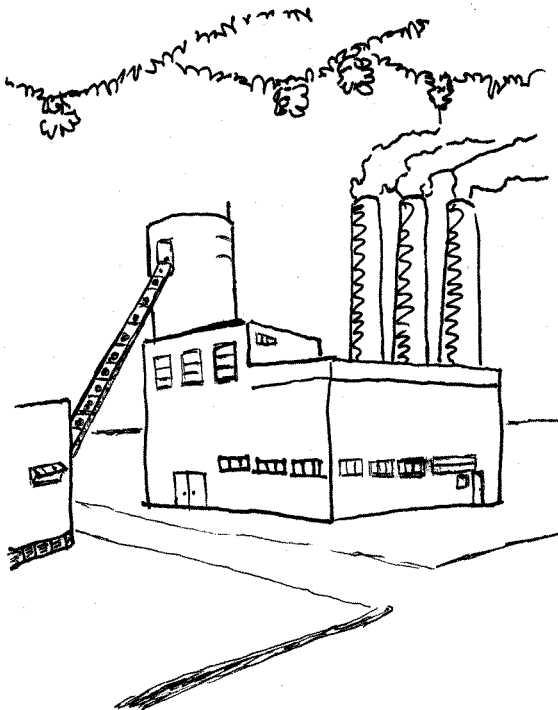
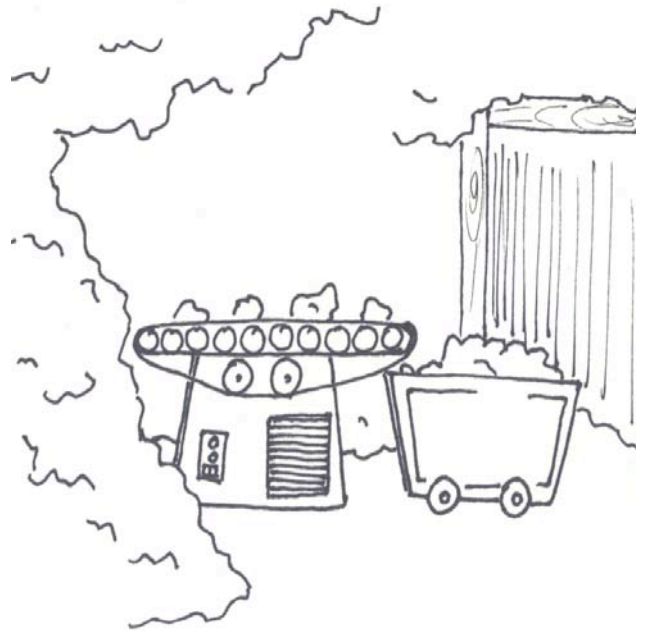
Natural Gas Picture Story Pack (1 of 2)



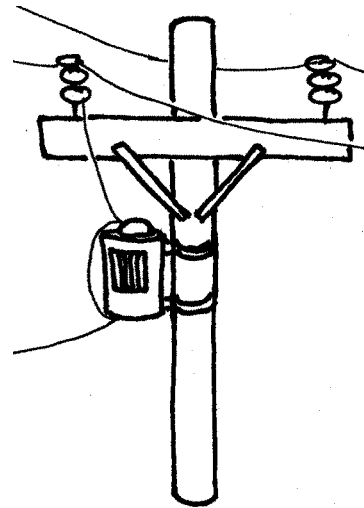
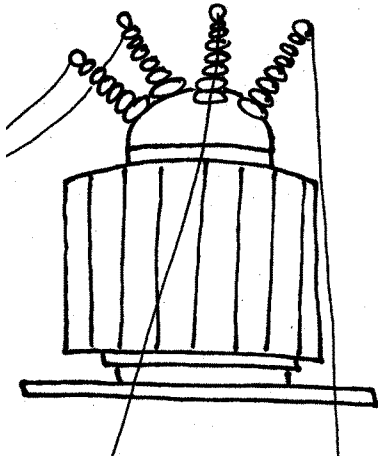
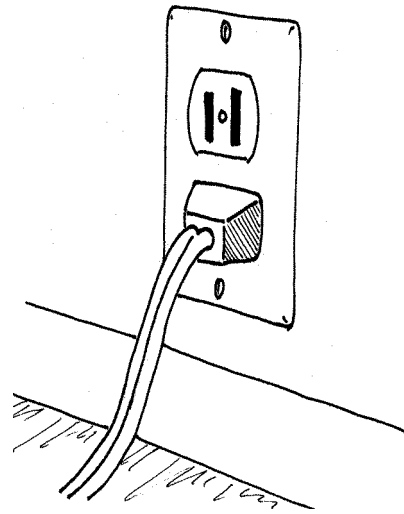
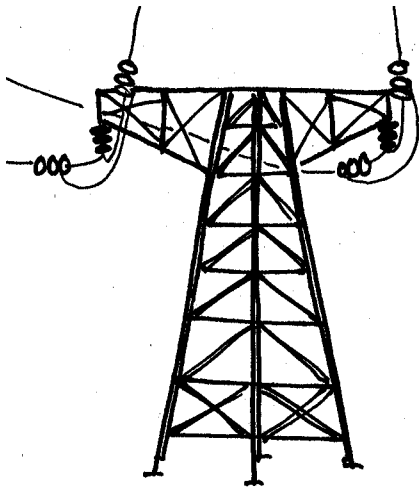
Natural Gas Picture Story Pack (2 of 2)

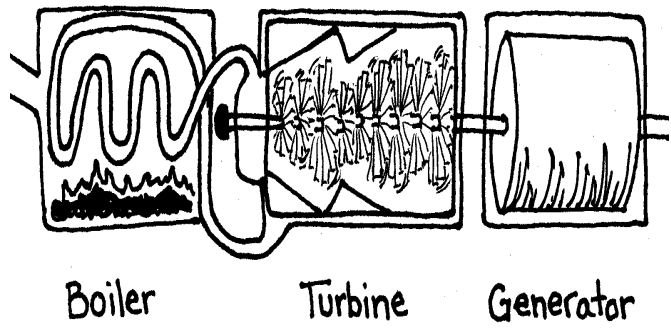
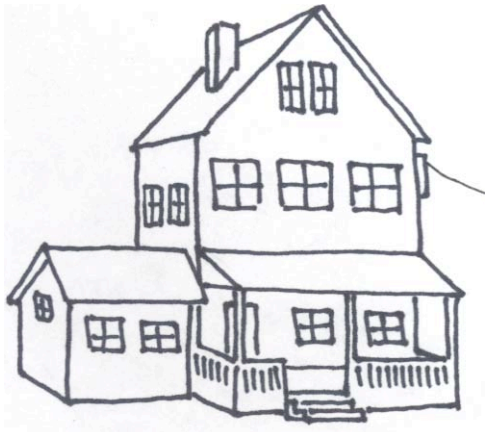


Electricity from Coal Picture Story Pack (1 of 2)

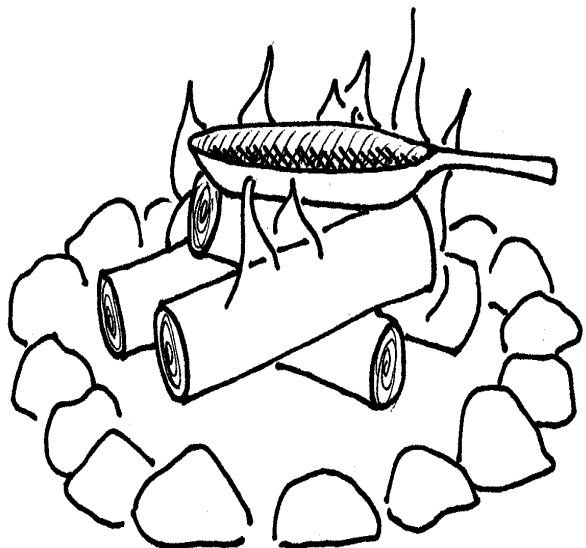
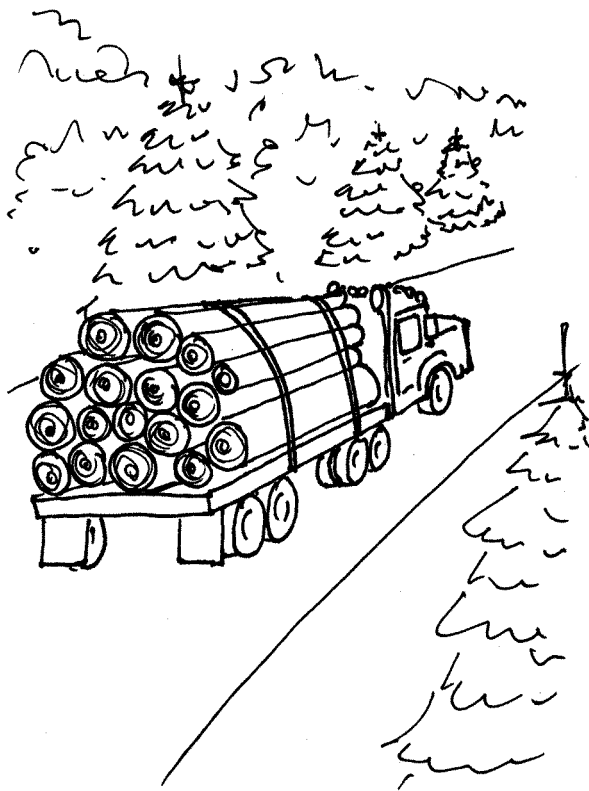
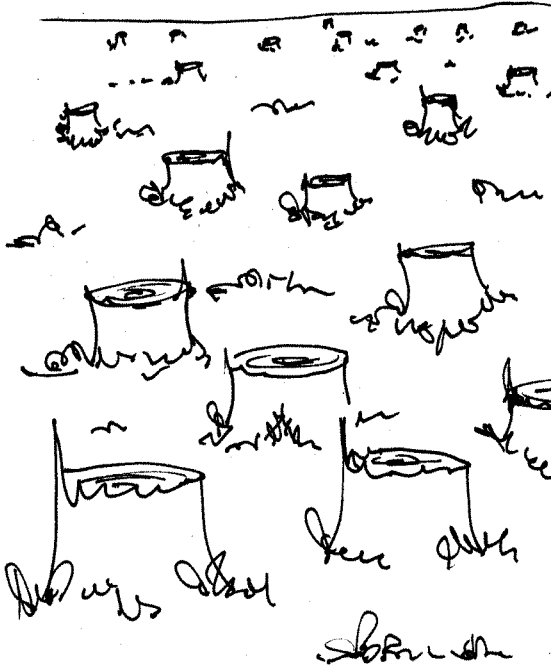


Electricity from Coal Picture Story Pack (2 of 2)

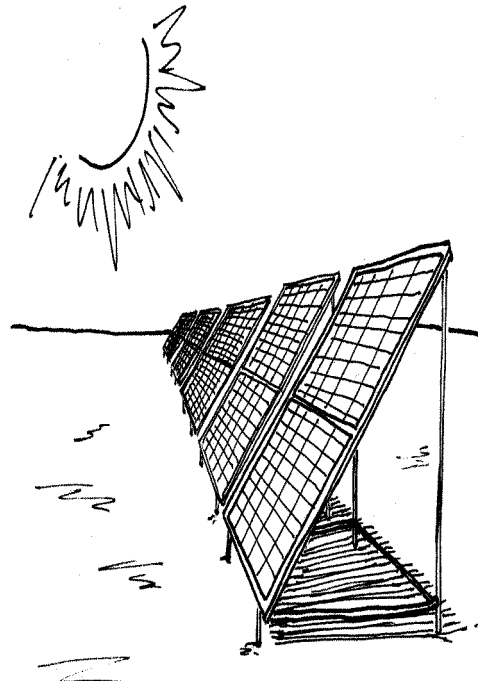
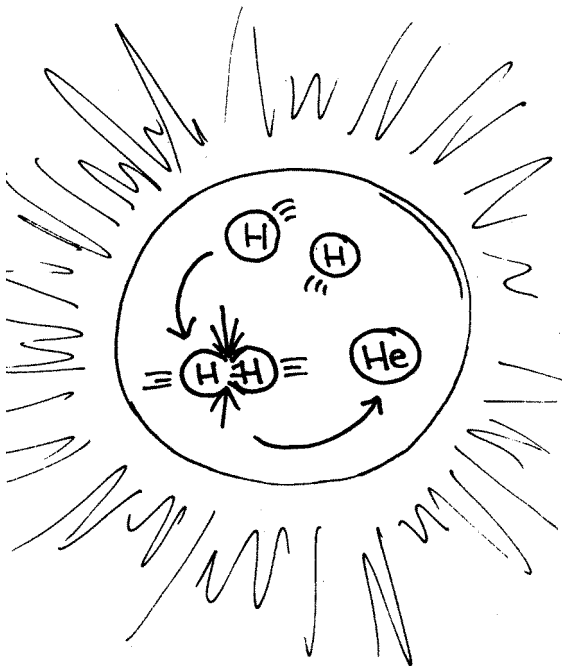
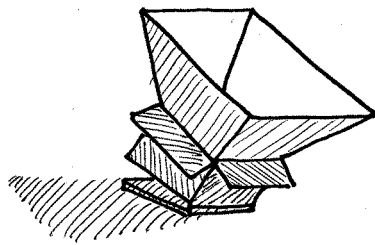
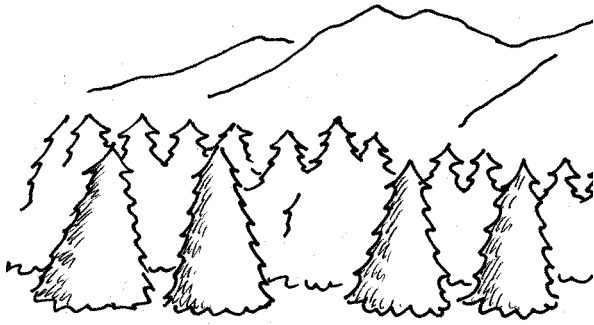




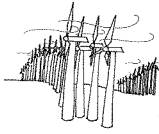
Wood Picture Story Pack (1 of 1)



Solar Picture Story Pack



Generating Energy: a cursory glance / brief descriptions



Wind: When a windmill is being used to generate electricity, the wind turns the vanes of the windmill. The vanes turn a generator. The generator makes the electricity. (When using highly efficient windmills—wind generators—this is the least expensive and cleanest source of energy. Wind generated electricity is also the fastest growing source of renewable energy in the world).



Cowley Ridge North/Sinnot

Operator: Canadian Hydro Developers Inc

Configuration: 20 X 1.3 MW N60

Operation: 2001

WTG supplier: Nordex

Quick facts: These were the most powerful wind turbines in Canada at completion.

Photograph courtesy of Nordex Posted 16 Nov 2003

<http://www.industcards.com/wind-canada.htm>



Redwood Falls

Location: Minnesota

Operator: Southern Minnesota Municipal Power Agency

Configuration: 2 X 950-kW NM54

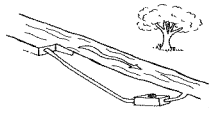
Operation: 2003

T/G supplier: Micon

Quick facts: The project cost about \$2.1mn.

Photograph courtesy of Southern Minnesota Municipal Power Agency Posted 9 Jul 2005

<http://www.industcards.com/wind-usa-mw.htm>



Hydro: Falling water is used at a hydro-electric plant to generate electricity. The turbines turn a generator. The generator makes the electricity.

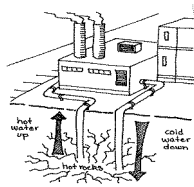


Title:

Ice Harbor Dam located on the Snake River near Burbank, Washington

Credit:

US Army Corps of Engineers



Geothermal: The hot water or steam from inside the earth spins the turbines. The turbines turn the generator. The generator makes electricity.



Title:

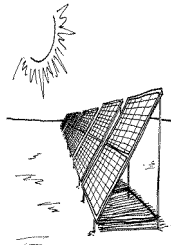
Geothermal power plant generator in Imperial County, California

Caption:

The Leathers geothermal power plant is located in the Salton Sea (geothermal resource area) located in southeastern California (just 60 miles east of San Diego). It is part of the Imperial Valley Partnership Project and is under contract to sell power to Southern California Edison Company under a 30-year power purchase agreement. The combined capacity at Imperial Valley is about 268 net MW (nominal).

Credit:

Gretz, Warren



Solar: A solar cell is any device that directly converts the energy in light into electrical energy through the process of photovoltaics. When sunlight strikes the surface of a PV cell, an electrical field is generated resulting in a flow of current when the solar cell is connected to an electrical load. (www.doe.gov)



Arizona Public Service

Quick Facts:

Arizona's state-mandated portfolio standards give concentrating PV a welcome boost. This Amonix installation for Arizona Public Service features dual-axis trackers and uses optical lenses to concentrate the sunlight onto cells within each square. The rectangular solar arrays, each standing in excess of 40 feet high, are concentrating solar arrays. Each of these arrays consists of from two to five very large modules — called megamodules. Each megamodule consists of concentrating lenses that focus the sunlight onto a very small photovoltaic cell.

Credit:

McConnell, Robert



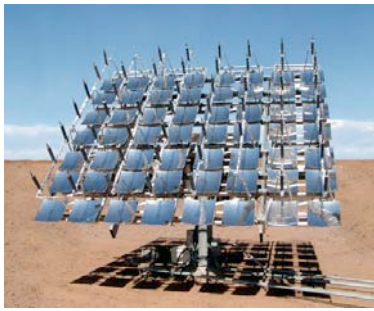
Lancaster, South Carolina

Quick Facts:

This photovoltaic system, installed on a home and home business in Lancaster, South Carolina, is grid-tied. The 910-kW system, was installed by South Carolina Solar, provides five-day backup power.

Credit:

South Carolina Solar



Arizona Public Service

Quick Facts:

The MicroDish is made by Concentrating Technologies using Spectrolab solar cells. It is the world's first grid-tied high-concentration CPV system to use the latest high-efficiency cells. The dual-axis tracking modules use small mirrors to focus sunlight on high-efficient multijunction cells. Individual fins extend outward to cool each cell. The MicroDish is supplying electricity to the Arizona Public Service grid.

Credit:

Arizona Public Service



Denver, Colorado

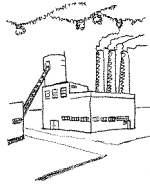
Zero energy habitat home; NREL's 2005 Habitat for Humanity house

Quick Facts:

This Habitat house now is looking like home. The solar thermal collectors and photovoltaic panels have been installed. This home is super insulated, very tightly constructed and designed for passive solar gain to reduce heating loads to a small fraction of the requirements of an average Denver home. A heat recovery ventilation system will assure indoor air quality while recovering ventilation air thermal energy. A highly efficient, greatly downsized heating system will meet the remaining space heating needs. The home is equipped with a solar water heating system and a substantial PV array. The PV array will be grid connected and sized to produce excess energy in the summer to balance out the excess consumption in the winter leading to net zero energy consumption.

Credit:

Beverly, Pete



Coal: Coal is mined from deep inside the earth, chiseled out, and carried to the surface. The coal is then shipped, primarily by railroad, throughout the country to power plants. The coal is the fuel for a power plant's boiler. The burning coal creates steam that is used to spin the turbines and in turn spin the generator.



Belle River, Michigan

Operator:

Detroit Edison Company

Fuel:

subbituminous coal boiler

Quick Facts:

Michigan Public Power Agency (MPPA) owns 18.6% of Belle River. In 1981, Detroit Edison agreed to maintain part of the 2,200 acre site specifically for wildlife preservation. This was certified by the Wildlife Habitat Council in 1996. Belle River has also received ISO 14001 certification.

Photo Credit:

Lansing Board of Water & Light, 18 September 2005

<http://www.industcards.com/st-coal-usa-mi.htm>



Jharkhand, India

Operator:

Damodar Valley Corporation

Fuel:

Hard coal boiler

Photo Credit:

Ministry of Power, 12 May 2004

<http://www.industcards.com/st-coal-india.htm>

Nuclear: Uranium is the fuel used in nuclear power plants. But, uranium must undergo a process called fission in order to create the heat necessary to make high-pressure steam. formed into small (about the diameter of a dime) pellets and arranged in



The Cook Energy Center

Location:

Located on 650 acres on the shoreline of Lake Michigan near Bridgman, MI.

Quick Facts:

There are two pressurized water reactors. Unit 1 is rated at 1,020 megawatts. Unit 2 is rated at 1,090 megawatts. Cook Unit 1 is one of the leading nuclear power generators in the United States, producing 143,000,000 megawatt hours through 1998.

Photo Credit:

www.cookinfo.com



Shearon Harris Nuclear Power Plant

Location:

Near Raleigh, North Carolina

Quick Facts:

The dome-shaped structure is the containment building.

Photo Credit:

<http://www.howstuffworks.com/nuclear-power.htm>

from the on-line article, "How Nuclear Power Works" by Marshall Brain

Notes To Teachers for Lesson 3

WORLDWIDE ENERGY USE:

United States:

Even though the United States accounts for 5% of the world's population, we consume 25% of the available supply. That places us as the world leaders of per-capita energy use. The typical American family spends nearly \$1300 per year on home utility bills. The burning of coal, oil, and natural gas for energy accounts for 85% of carbon dioxide emissions and the largest contributor to air pollution.

World-wide:

Energy use and population are not evenly distributed throughout the world. As a result, two issues become inextricably joined: a growing number of people need access to energy sources *and* large consumers of energy need to decrease their energy consumption. There are a finite amount of fossil fuel sources available. The chart below compares the percentage of population and energy use in different regions of the world. As you will see, overall energy consumption and per capita energy use do not directly correlate to percentage of population. What effect does this uneven distribution of energy use have on societies? One main result is that impoverished, 'undeveloped', countries remain that way. Another is countries may use alternatives to fossil fuel burning for their energy sources.

World Population and World Energy Use

Country/Region	% World Population	% Energy Consumption	Per Capita Energy Use (kg)
Middle East / North Africa	4.9%	4.8%	1,374
North America	5.2%	28.6%	7,823
Latin America / Caribbean	8.4%	5.7%	960
Sub-Saharan Africa	10.1%	1.7%	237
Europe / Central Asia	15.4%	33.6%	3,097
South Asia	22.0%	3.4%	222
East Asia / Pacific	33.9%	22.2%	934

The above statistics were compiled by Zero Population Growth.

Global Warming: A working definition

Technically, the term(s) global warming or global cooling refer to the natural warming and cooling trends that the earth has experienced all through its history. However, the term “global warming” has become a popular term encompassing all aspects of the global warming problem, including the potential climate changes that will be brought about by an increase in global temperatures.

(www.climatechangecentral.com/default.asp)

This term has become popularized and is currently used to express an extremely different set of circumstances—than the natural warming trends throughout history—the world’s population is now facing.

For the first time in history, people are the direct cause of the warming of the planet. This unprecedented event is upsetting the balance of nature causing climatic shifts that even thus far have proven to be disastrous for all life. The current rate of habitat loss, increase in storm severity, increase in pollution induced illnesses, and the increase in death, and malformation of those living in areas that are exposed to polluted foods, land, and water is intensifying at an alarming rate around the globe.

It is of the utmost importance for the youth of today to have a conscious awareness of their direct complicity in the warming of the planet and to then decide how they might or might not change their actions that directly affect the health of all life on the planet and the life of the planet itself.

Therefore, an encompassing, working definition of global warming can be thought of as:

A gradual warming of the Earth’s atmosphere caused by the burning of fossil fuels and industrial pollutants.



Photograph courtesy of Greenpeace. Blomstrandbreen Glacier in Svalbard, Norway. Taken in 1918 (top) and today (bottom), this photograph illustrates the retreat of the glacier approximately 2 km in the past 80 years. Since 1960, the average retreat of that glacier has been about 35 m a year, accelerating in the last ten years.

The Greenhouse Effect

Global warming is often explained through the example of the greenhouse effect. In a greenhouse—a building made of glass or clear plastic—the sun shines through the walls and the heat is trapped inside. The same basic principle applies for regulating the temperature of the earth.

The earth's atmosphere is a complicated system of gases and energy. It allows energy from the sun to pass through to the earth and also allows energy from the earth to escape into space. By delicately balancing this exchange of energy, the atmosphere regulates our climate.

A blanket of invisible gases surrounds the earth. These gases make up the earth's atmosphere. When the sun shines through the earth's atmosphere onto the earth, certain gases such as carbon dioxide and water vapor trap the heat of the sun close to the earth. This is important, because without this blanket of gases, the earth would be very cold and uninhabitable. As the earth absorbs the sun's warmth, it reflects the heat back toward space. When the earth's atmosphere takes in more energy than it releases, this causes the earth to become warmer.

The burning of coal, oil, and natural gas has increased the concentration of certain gases in our atmosphere. Factories, electric power plants, and vehicles that burn fossil fuels to create energy are raising the level of carbon dioxide in the atmosphere.

How does this happen? Fossil fuels consist primarily of hydrocarbons. Hydrocarbons are atoms created from hydrogen and water. When hydrocarbons burn, the carbon combines with oxygen to produce carbon dioxide. When excessive amounts of carbon dioxide build up in the atmosphere, more and more of the sun's heat is trapped in the atmosphere surrounding the earth. In this scenario, rate of greenhouse gas increase exceeds the rate of absorption. The result is a human activity induced climate warming. Carbon dioxide is one of the greenhouse gases believed to cause global warming; others are methane, nitrous oxide, and chlorofluorocarbons (CFCs).

How is this a problem? A rise in temperature, even a degree, can wreck havoc on the balance of ecosystems. At this point, scientists have documented an increase of nearly one degree Fahrenheit in the past century. The rising global temperatures are the most serious threat of global warming.

The Warming Trend: Can a few degrees make a difference?

Throughout history, major shifts in temperatures have occurred at a very slow rate—usually changing only a few degrees over thousands of years. However, over the last century, scientists have documented a 1° F rise in the temperature of the planet. If temperatures continue to rise at this rate, climate scientists predict that global warming will raise the average temperature of the planet by 3 to 10 degrees Fahrenheit over the next 80 years.

How much of a difference can a few degrees make? The answer is simply: a few degrees in global temperature change can have drastic affects on the planet. The warming trend increases the intensity of both droughts and storms such as hurricanes, tornadoes, and flooding. Since 1995, more than 5,400 square miles of Arctic ice shelves have melted causing rises in sea-levels around the world. Given that 70% of the earth's surface is covered by water, low-lying parts of the world are now much more vulnerable to flooding and the devastation that follows.

Variability in temperature, precipitation, soil moisture, humidity, and wind can increase susceptibility or growth of diseases and pest resistance, and change the natural occurrence of fires, droughts, and floods. Varieties of plants and animals including coral reefs and pine forests are incapable of shifting habitat and are in rapid decline. Climate shifts can also affect food supplies, and the availability of shelter, space, and water for all.

This change in climate is likely to accelerate in the next century and could continue until several decades after the greenhouse gas concentrations reach a peak. (When that peak occurs specifically depends on how we choose to live our lives).



As studies suggest, according to the EPA (Environmental Protection Agency), breathing smoggy air containing fine pollution particles can be as dangerous as breathing second hand cigarette smoke. (Photo courtesy EIA: the air over the Los Angeles, California is hazy with pollution).

Global Warming and Increased Health Problems

Infectious disease is the second major threat that global warming poses to human health. Scientists at Harvard Medical School have linked recent U.S. outbreaks of dengue fever, malaria, and hantavirus to climate change. As temperatures increase, formerly cool areas become new habitats for disease-carrying mosquitoes and rodents. These creatures are the vectors for diseases that more commonly thrived in tropical climates.

Since 1990, outbreaks of locally transmitted malaria have occurred in California, Florida, Georgia, Michigan, New Jersey, and New York. The Intergovernmental Panel on Climate Change (IPCC) predicts that as warmer temperatures spread north and south from the tropics and to higher elevations, malaria-carrying mosquitoes will spread with the shifting climates. This may put as much as 65% of the world's population at risk of infection. This is an increase of 20% within the next century.

Energy Sources

NATURAL GAS:

As of 1998, natural gas provided 21% of all the energy produced worldwide.* Natural gas is a fossil fuel and as all fossil fuels—oil, coal, and gas—is extracted from the earth. Once fossil fuels are extracted they cannot be replaced and a finite amount of these fuel sources exist. New natural gas technologies using combined cycle combustion turbines produce energy more efficiently with fewer emissions than older gas plants. Essentially, these systems capture the waste heat that is used to make high pressure steam to do something useful and not let that energy heat the atmosphere.

Fewer emissions equal less contribution to creating smog and acid rain. The new technologies for natural gas still rely on mining natural resources, and cause habitat destruction and loss, but use cleaner, safer practices to make energy.

*(Wasserman, Susan. “Energy Futures” Earth Matters: Studies for Our Global Future. Washington D.C.: Zero Population Growth, 2nd ed., 1998, p.125)

ELECTRICITY:

THE BASICS: How Electricity is Generated

Making electricity is a mechanical process. A fuel (coal, natural gas, nuclear power, oil, wood) is used to heat a boiler that makes high pressure steam. The steam that is made spins a turbine. The turbine spins a generator. The generator makes the electricity.

The following are a few examples of how that process can play out:

- Windmill: When a windmill is being used to generate electricity, the wind turns the vanes of the windmill. The vanes turn a generator. The generator makes the electricity. (When using highly efficient windmills—wind generators—this is the least expensive and cleanest source of energy. Wind generated electricity is also the fastest growing source of renewable energy in the world.)
- Hydro: When falling water is used at a hydro-electric plant to generate electricity, the waves smash into turbines. The turbines turn a generator. The generator makes the electricity.
- Geothermal: The hot water or steam from inside the earth spins the turbines. The turbines turn the generator. The generator makes electricity.

***** Oftentimes, 60-70% of the net energy created is lost as heat. This heat loss is called ‘waste heat’ and is created when the generator makes the electricity. This waste heat heats the atmosphere. Out of 100 units of electricity generated, barely 30 units of useable electricity are available in a typical electricity generating situation. *****

WOOD:

More than 2 billion people world-wide depend primarily on wood for their energy needs. Biomass burning leads to deforestation and contributes up to 40 percent of global greenhouse gas emissions. It’s also firmly linked to acute respiratory infection, which is the leading health hazard to women and children in developing countries as well as lung and eye disease. In countries where wood has been traditionally relied on as the primary energy source, fuel wood is

becoming scarce. In cultures that depend on fuel wood as their primary energy source for cooking, three hours per day is typically spend gathering wood.

Potential Energy and Energy Conversion Table for Teachers:

Potential Energy	Energy Conversion
<p>Natural gas</p> <p>Potential energy source: natural gas</p>	<p>Natural gas is mined from deep inside the earth, pumped out, and then shipped to the gas supply facility in your state. It is then distributed to a regional power supply company. In Michigan, one of the power companies is Consumers Energy.</p> <p>Natural gas pipelines are laid deep in the ground throughout your town and neighborhood. Some houses, but not all, have pipes connecting the larger pipes in your neighborhood to the smaller natural gas lines in your house. If you have a gas stove, the stove has gas lines connecting it to the larger gas lines in your house that are connected to the even larger gas lines in your neighborhood that are connected to the even larger gas line piping network throughout your town where those pipes are connected to the main supply area.</p> <p>Energy Conversion: chemical energy to thermal energy</p> <ul style="list-style-type: none"> • Turn on the gas: methane is released in the air (clicking sound that many stoves make, there is a second or so after you turn on the dial to light the stove before the gas ignites—that is when the methane is released) (mechanical to chemical) • The methane reacts with the oxygen in the air and a spark happens (chemical to chemical) • The spark ignites the natural gas from the burners (chemical to chemical) • The ignited natural gas is now undergoing combustion (it is burning) and maintains a flame (chemical to chemical) • The flame produces heat (chemical to thermal) • The heat is transferred to the pan on the stove (thermal to thermal) <p>The heat from the pan is transferred to the food or water in the pan (thermal to thermal)</p>
<p>Electricity—coal burning</p> <p>Potential energy source: coal</p>	<p>Coal is mined from deep inside the earth, chiseled out, and carried to the surface. The coal is then shipped, primarily by railroad, throughout the country to power plants.</p> <p>Burning coal (and oil) creates sulfur dioxide, nitrogen oxide, and carbon dioxide. These gases are the main contributors to creating acid rain, smog, and global warming. The mining technologies cause habitat destruction and loss, and pose severe health risks often leading to fatal disease (black lung disease of coal miners) for the workers.</p> <p>Energy Conversion: chemical energy to electrical energy to thermal energy</p> <ul style="list-style-type: none"> • As the coal burns, it produces heat (chemical to thermal) • The heat from the coal burning turns the turbine (thermal to mechanical) • The turbine creates electricity (mechanical to electrical) • The electricity in your stove coils heat when turned on (electrical to thermal) • The heat is transferred to the pan on the stove (thermal to thermal) <p>The heat from the pan is transferred to the food or water in the pan (thermal to thermal)</p>

<p>Electricity—high impact hydro Potential energy source: falling water</p>	<p>In order to build a hydro-electric plant, rivers must be dammed. Dams change a river's natural flows and endanger fish and other species habitat and livelihood. Dams often cause degraded water quality, depleted food sources, and block migratory pathways all leading to threatening species survival.</p> <p>Energy Conversion: mechanical energy to electrical energy to thermal energy</p> <ul style="list-style-type: none"> Falling water turns the turbines (mechanical to mechanical) The turbines create electricity (mechanical to electrical) The electricity in your stove coils heat when turned on (electrical to thermal) The heat is transferred to the pan on the stove (thermal to thermal) The heat from the pan is transferred to the food or water in the pan (thermal to thermal)
<p>Electricity—nuclear Potential energy source: nuclear energy</p>	<p>Although nuclear reactor plants do not create smog-emissions, nuclear plants do create dangerous radioactive wastes that are difficult to dispose of and last for 235,000 years. No permanent safe storage sites exist in the world for the waste.</p> <p>Energy Conversion: chemical energy to thermal energy</p> <ul style="list-style-type: none"> The waste heat from the nuclear energy reactors are used to turn the turbines (thermal to mechanical) The turbines create electricity (mechanical to electrical) The electricity in your stove coils heat when turned on (electrical to thermal) The heat is transferred to the pan on the stove (thermal to thermal) The heat from the pan is transferred to the food or water in the pan (thermal to thermal)
<p>Electricity—geothermal Potential energy source: hot water or steam inside the earth</p>	<p>Geothermal electricity is generated by utilizing steam or hot water that lies below the surface of the earth in certain locations. In the United States, states located in western and southwestern parts of the country are geothermally active.</p> <p>Geothermal plants produce and emit little air pollution.</p> <p>Energy Conversion: thermal energy to thermal energy</p> <ul style="list-style-type: none"> The heat from the geothermal plant is used to turn the turbines (thermal to mechanical) The turbines create electricity (mechanical to electrical) The electricity in your stove coils heat when turned on (electrical to thermal) The heat is transferred to the pan on the stove (thermal to thermal) The heat from the pan is transferred to the food or water in the pan (thermal to thermal)

<p>Electricity–biomass Potential energy source: organic wastes</p>	<p>Biomass facilities use the energy that is stored in organic matter to make electricity. These facilities burn wood, agricultural wastes, or methane gases from landfills to spin a turbine that generates electricity.</p> <p>Energy Conversion: chemical energy to thermal energy</p> <ul style="list-style-type: none"> • Organic wastes or wood is burned (chemical to chemical) • The combustion reaction produces heat (chemical to thermal) • The heat is used to turn the turbines (thermal to mechanical) • The turbines create electricity (mechanical to electrical) • The electricity in your stove coils heat when turned on (electrical to thermal) • The heat is transferred to the pan on the stove (thermal to thermal) • The heat from the pan is transferred to the food or water (thermal to thermal)
<p>Wood Potential energy source: wood fibers</p>	<p>Different woods have different amounts of embodied energy. Dense, dry woods have the highest embodied energy. For example, seasoned oak has more embodied energy than pine. So, the type of wood that is being burned is very important.</p> <p>More than 2 billion people world-wide depend primarily on wood for their energy needs. And, in countries where wood has been traditionally relied on as the primary energy source, fuel wood is becoming scarce. Deforestation leads to siltification of rivers, land erosion, and soil nutrient depletion. This then in turn affects crop yields, drinking water quality / availability, species destruction, and decline in species populations of plants and animals.</p> <p>The pollution from burning wood for fuel has been linked to acute respiratory infection, lung disease, and eye disease. Acute respiratory infection is one of the leading health hazards to women and children in developing countries. In countries where wood has been traditionally relied on as the primary energy source, fuel wood is becoming scarce. In these areas of wood scarcity the typical amount of time spent gathering wood is 3 hours.</p> <p><i>**Even though wood is considered a renewable resource it is important to discuss the issues around the amount of time it takes for a tree to reach maturity. This topic could be an excellent assignment for writing a persuasive essay. Very few stands of old growth trees remain—many trees that were hundreds of years old have been cut down. It is important for the students to recognize that if you cut a tree down a new tree is not a direct replacement. Important issues for extrapolation / student research: habitat, forest ecosystem, soil health, soil erosion, forest management.</i></p> <p>Energy Conversion: chemical energy to thermal energy</p> <ul style="list-style-type: none"> • Organic wastes or wood is burned (chemical to chemical) • The combustion reaction produces heat (chemical to thermal) • The heat is transferred to the pan from the fire (thermal to thermal) • The heat from the pan is transferred to the food or water (thermal to thermal)

<p>Solar Potential energy source: the sun</p>	<p>Solar energy is radiant energy from the sun that travels to earth in electromagnetic waves (or rays). Solar energy is produced in the sun's core when atoms of hydrogen combine under pressure to produce helium, in a process called fusion. During fusion, radiant energy is emitted.</p> <p>Solar energy is harnessed with solar collectors that turn the radiant energy into heat. Photovoltaic cells turn radiant energy into electricity. We also use solar energy to see.</p> <p>Solar energy is not available all the time—in darkness or when dense cloud cover is present. At this point, it is expensive to use solar energy to produce electricity, but new technologies will make solar energy a major energy source in the future.</p> <p>Solar energy is a very clean energy source, producing no air or water pollution.</p> <p>Energy Conversion: electromagnetic energy to thermal energy <i>A solar cell is any device that directly converts the energy in light into electrical energy through the process of photovoltaics. A typical silicon PV cell is composed of a thin wafer consisting of an ultra-thin layer of phosphorus-doped (N-type) silicon on top of a thicker layer of boron-doped (P-type) silicon. An electrical field is created near the top surface of the cell where these two materials are in contact, called the P-N junction. When sunlight strikes the surface of a PV cell, this electrical field provides momentum and direction to light-stimulated electrons, resulting in a flow of current when the solar cell is connected to an electrical load. The current (and power) output of a PV cell depends on its efficiency and size, and is proportional to the intensity of sunlight striking the surface of the cell. Because of this, a typical commercial solar cell has an efficiency of about 1/6 of the sunlight striking the cell generates electricity. The first solar cells, built in the 1950s, had efficiencies of less than 4%. (The above information taken directly from Department of Energy website (www.doe.gov))</i></p>

Lesson 4: 4th grade

Radiant Energy

Lesson Overview: The sun's energy (electromagnetic energy) provides us directly with heat and light.

Lesson Concept: Electromagnetic energy (solar energy) is vital to our world.

Materials:

- Clamp light
- Extension cord
- Incandescent light bulb
- IR Thermometer
- Student hand-out (or use as overhead): Absorption and Reflection

Standards:

- **Mathematics:**
 - **II.3.LE.5** (Geometry and Measurement: Explore scale drawings, models and maps and relate them to measurements of real objects).
 - **II.3.LE.6** (Geometry and Measurement: Apply measurement to describe the real world and solve problems).
- **Science:**
 - **II.1.LE.4** (Reflect on the Nature, Adequacy, and Connections Across Scientific Knowledge: Develop an awareness of and sensitivity to the natural world).
 - **IV.1.LE.4** (Use Scientific Knowledge from the Physical Sciences in Real-World Contexts: Identify forms of energy associated with common phenomena).

Timeline: 1 class period (40 – 50 minutes)

Class Structure: whole class experiments and discussion

Assessment Strategy: EEK! Daily Assessment
Pre-Module Assessment Question #2

Lesson 4: 4th grade Radiant Energy

This lesson is devoted to investigating the one renewable energy source we have discussed so far—solar energy. This lesson explores how and how much of the sun's energy reaches the earth.

Lesson Overview: The sun's energy (electromagnetic energy) provides us directly with heat and light.

Lesson Concept: Electromagnetic energy (solar energy) is vital to our world.

Supplies Needed:

- Clamp light
- Extension cord
- Incandescent light bulb
- IR Thermometer
- Student hand-out (or use as overhead): Absorption and Reflection

Background Information:

Please share this background information with the students at some point in this lesson.

I. The Power of the Sun

Energy from the sun reaches Earth in the forms of heat and light. This energy is the driving force behind creating wind, weather, and seasons. We may not often think of the sun as having so much power, but if the earth was located closer or further away from the sun, it would most likely not be a place where life could thrive. So, in other words, we owe our life to the sun!

II. Basic Sun Statistics

- a. The sun is very large compared to the size of Earth.
- b. The sun's diameter (1,380,000 kilometers) is about 110 times Earth's diameter.
- c. If you thought of the sun as a large bowl, it could hold more than 1 million Earths.
- d. Even though the sun and the moon appear to be nearly the same size, the sun is located 400 times further away from Earth than the moon.
- e. The sun is very hot. The surface temperature of the sun is about 5500°C (6000°K)

(The above information from *Earth Science*, Spaulding, Nancy and Samuel Namowitz, D.C. Heath and Company, Lexington, MA, 1994, p. 398)

III. The Solar System and the Sun's Energy

The earth is part of a larger system called the solar system. The solar system is comprised of 8 planets. Within this system, the earth is the 3rd planet from the sun.

- A supersonic jet can fly from Paris to New York in about 3 1/2 hours. If a supersonic jet could fly through space at the same speed, it would take about 10 years to reach the sun. That is how far away the sun is from Earth.

Teacher's Note:	At the end of this lesson are more detailed teacher resource materials.
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CLASS EXERCISES:

Sun Experiments:

The following experiments attempt to demonstrate:

- Heat of the sun
- Distance between Earth and sun

Experiment #1: Heat of the Sun

Turn on a clamp light with an incandescent bulb and let it get hot (Make sure the students wet their fingers before touching the bulb so they don't get burned!) Let the student's touch the bulb to feel how hot it is.

Statistics:

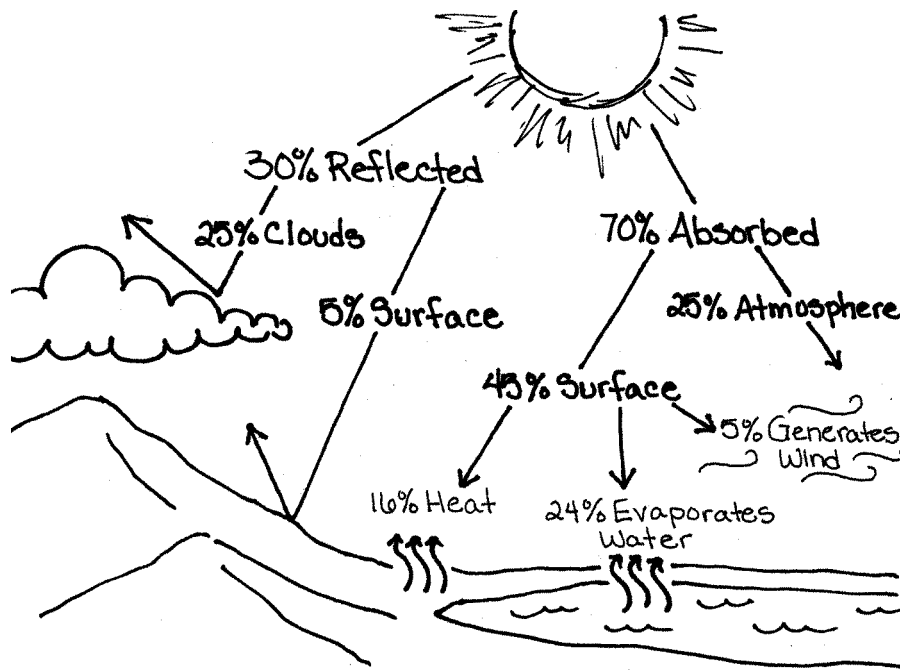
- The surface of the light bulb is approximately $x^{\circ}\text{F}$
 - Measure the bulb temperature with the IR Thermometer
- The sun is x times hotter than that bulb
 - Work this problem out on the board
 - Have the students guess how much hotter the sun might be before solving the problem

Experiment #2: Distance between Earth and Sun

Have the students create a circle in the middle of the room that is (x feet around). This circle represents a scale version of the earth. Ask the students, "if this circle represents the size of the earth, how far away do you think the sun would be?" Figure out scale dimension and place where sun would be. Sun to earth distance = 1.498×10 to the 11^{th} m

IV. Absorption and Reflection

Look at the diagram below:



Jessica Western and Matt Isaacson

Questions:

- How much of the sun's energy (solar energy) reaches Earth?

70% of the sun's energy reaches Earth.

- What happens to solar energy when it reaches Earth?

It is absorbed. This happens in a variety of ways. Imagine what happens when you lie in the sun on a warm day. Most of the 70% of the sun's energy is absorbed by solid materials and water and is almost immediately converted to heat. Any material that is heated by the sun will radiate heat outward. Sometimes you can see this on a hot day as heat waves shimmering in the air above hot pavement. Eventually, the absorbed heat will radiate through the atmosphere and leave the planet.

- How much of the sun's energy does not reach Earth?

30% of the sun's energy never reaches the earth's surface.

- What happens to the sun's energy that does not reach Earth?

It is immediately reflected back as light to outer space. Most of this reflected light bounces off the clouds and never reaches the surface of Earth. But, some of the 30% does reach the surface but bounces off snow and water leaving Earth in the form of light. This reflected light makes Earth visible from space—it is also how we have daylight.

- How does the sun's energy influence the water cycle of Earth?

A large amount of the sun's energy, approximately 24%, evaporates water. This process powers the water cycle. Essentially, when the sun shines onto the earth it evaporates water in oceans, rivers, and lakes. Evaporated water is water vapor. The water vapor rises into the atmosphere and forms clouds. The water vapor cools, condenses, and falls to the earth as snow, rain, sleet, hail or another form of precipitation. (NEED curriculum)

When water evaporates it changes from a liquid state to a gas state when it becomes water vapor. Then, when the water vapor condenses back to the liquid state (precipitation), the same amount of energy released to turn it into water vapor is the same amount that was absorbed to turn the

condensed water vapor into precipitation. Therefore, even the incoming sunlight that powers the water cycle (hydrologic cycle) also eventually leaves the earth in the form of heat.

V. Using Solar Energy

Imagine what happens when you lie in the sun on a warm day—your body feels very warm, perhaps even hot. That warmth is created from your body absorbing the sun’s energy in the form of heat. Can you imagine what the heat from the sun could be used to do? (hint: how do you make food?) Cook food!

A Brief History of Cooking with the Sun: Using Solar Ovens

- Recorded history of cooking with solar ovens dates back to over 300 years ago.

In 1878, *Scientific American* published an article describing how a group of people successfully cooked a meal of meat and potatoes for seven people in Bombay, India.

- **What is a solar oven?**

A solar oven is basically an insulated box with an opening that has a cover made from transparent glass or plastic. The inside walls are either black or reflective.

- **How does a solar oven work?**

Solar ovens use the “greenhouse effect” to cook food. The sun’s energy—solar radiation—passes through the transparent cover made of glass or plastic. If the inside walls are black, the sunlight is absorbed and heats the inside of the oven and cooks the food. If the walls are reflective, the sunlight reflects onto the pot and heats it.

- **Can the ovens actually cook food?**

Yes. If using a design similar to Maria Telkes with reflector wings surrounding the opening of the oven, temperatures often reach 400° to 450° Fahrenheit and are suitable for any kind of cooking except frying. If using a box cooker (another solar oven design), maximum temperatures are usually lower. The box cooker has one reflector wing attached with a hinge so it can be tilted to adjust to the sun when necessary. A box cooker usually reaches around 250° to 300° Fahrenheit.

- **Are there many different kinds of solar ovens?**

Yes. There are solar ovens that look like big bowls with wings attached to the top of them. These designs are called parabolic cookers or concentrating cookers and do not have covers but are open to the air. They have been successfully used to stir-fry foods.

- **Where can solar ovens be used?**

Solar ovens can be used effectively anywhere there is a sunlight and a warm climate. The main issues affecting successful cooking with solar cookers are:

- type of food traditionally eaten
- climate (enough sunlight throughout the day and warm air climate)

- **What are the benefits from using a solar cooker?**

There are significant health advantages—ecosystem health and public health. Over 2 billion people in developing countries suffer from upper respiratory diseases due to inhaling wood

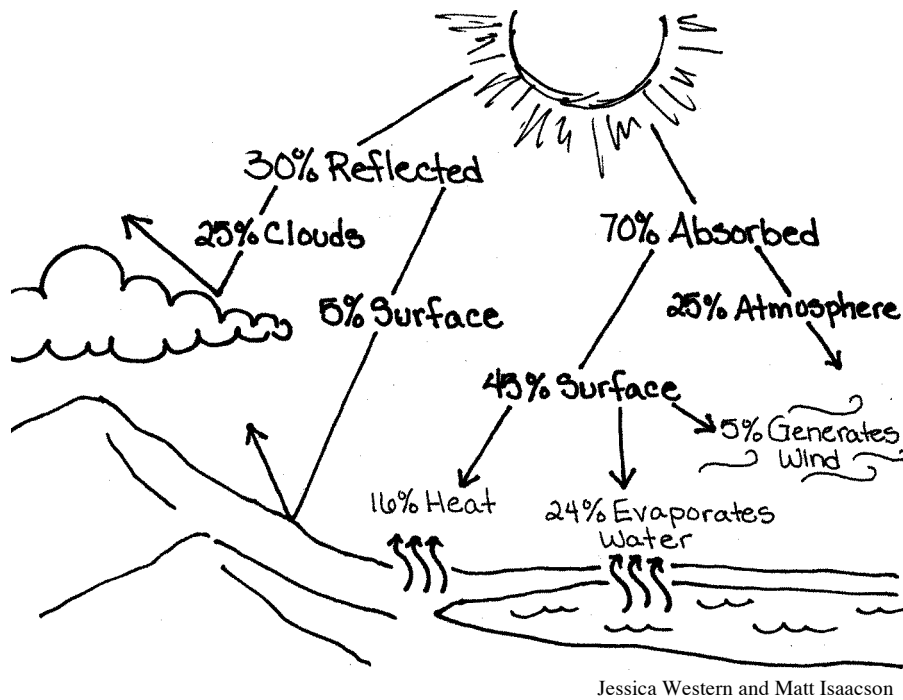
smoke. There is an average of 960 million tons of fuel wood burned for cooking per year. Using solar cookers worldwide could reduce fuel wood use by 350 tons per year. (UNICEF, Synopsis of Estimate of fuel saving potential of solar cookers, 1994)

- **Why don't more people use solar cookers?**

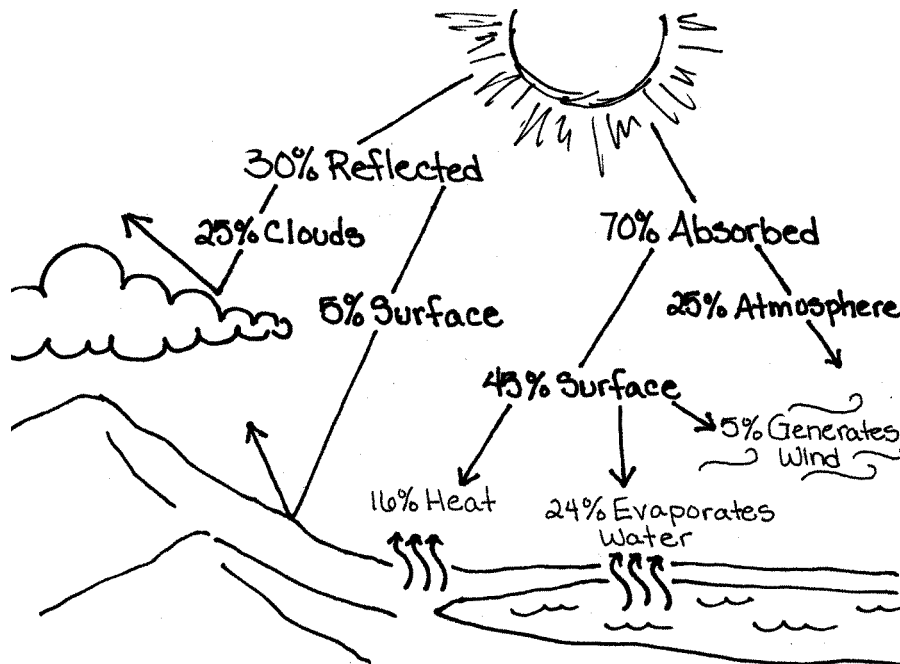
Cost, climate, and foods:

- **Cost:** The average cost for a wooden box solar cooker is \$40. The average Kenyan yearly income is \$400. Spending 10% of the total family income for the year is a significant purchase. Organizations promoting solar cooking are encouraging villages to build larger, communal style cookers. This can lower the overall cost per person and create a higher level of community “buy-in”.
- **Climate:** Solar cookers are most effective in warm, sunny climates.
- **Foods:** Grains, legumes, and breads cook best in a solar cooker as well as 1-pot stews. Many traditional foods require frying.

Absorption and Reflection
4th Grade



Teacher Resource Material for Lesson 4:



Jessica Western and Matt Isaacson

A few basic facts about the sun and radiant energy:

- The sun produces energy in its core when atoms of hydrogen combine under pressure to produce helium. This process is called fusion. Radiant energy—the energy from the sun—is emitted when fusion occurs. Essentially, the sun is one, very big, very hot energy source. While it may not last forever, scientists predict that the sun will continue to burn sending energy to earth for 5.5 billion more years.
- When solar energy reaches Earth, about 30% is immediately reflected back as light to outer space. Most of this reflected light bounces off of the clouds and never reaches the surface of Earth. But, of the 30% that does reach the Earth's surface bounces off of snow and water leaving Earth in the form of light. This reflected light makes Earth visible from space—it also is how we have daylight.
- The remaining 70% of the sunlight (the sun's energy) that reaches Earth is absorbed. This happens in a variety of ways. Imagine what happens when you lie in the sun on a warm day. Most of the 70% of the sun's energy is absorbed by solid materials and water and is almost immediately converted to heat. Any material that is heated by the sun will radiate heat outward. Sometimes you can see this on a hot day as heat waves shimmering in the air above hot pavement. Eventually, the absorbed heat will radiate through the atmosphere and leave the planet.
- A large amount of the absorbed heat, approximately 24%, evaporates water. This process powers the water cycle. Essentially, when the sun shines onto the earth it evaporates water in oceans, rivers, and lakes. Evaporated water is water vapor. The water vapor

rises into the atmosphere and forms clouds. The water vapor cools, condenses, and falls to the earth as snow, rain, sleet, hail or another form of precipitation.

- When water evaporates it changes from a liquid state to a gas state when it becomes water vapor. Then, when the water vapor condenses back to the liquid state (precipitation), the same amount of energy released to turn it into water vapor is the same amount that was absorbed to turn the condensed water vapor into precipitation. Therefore, even the incoming sunlight that powers the water cycle (hydrologic cycle) also eventually leaves the earth in the form of heat.
- No matter how energy is absorbed or changes form, it never increases or decreases in amount. All the solar energy that is absorbed on Earth in one form or another eventually changes to heat energy that radiates to outer space.
- Look at the following diagram to help explain the above points:

All of the above information is based on information from *Dr. Art's Guide to Planet Earth: for Earthlings ages 12 to 120*, Art Sussman, Ph.D. p. 48. Published by Chelsea Green 1-800-639-4099

Lesson 5: 4th grade
Mini Books: Maria Telkes and Solar Cooking

Lesson Overview: Solar ovens are being used to cook food around the world today.

Lesson Concept: Our everyday actions impact others around the globe.

Materials:

- Student hand-out: Mari Telkes Mini Book
- Markers / Colored Pencils / Pencils

Standards:

- **English:**
 - **IX.11.LE.1** (Inquiry and Research: Generate questions about important issues that affect them or topics about which they are curious, and use discussion to narrow questions for further exploration).
- **Mathematics:**
 - **II.3.LE.5** (Geometry and Measurement: Explore scale drawings, models and maps and relate them to measurements of real objects).
- **Science:**
 - **III.5.LE.5** (Use Scientific Knowledge from the Life Sciences in Real-World Contexts: Describe positive and negative effects of humans on the environment).
 - **IV.1.LE.4** (Use Scientific Knowledge from the Physical Sciences in Real-World Contexts: Identify forms of energy associated with common phenomena).
- **Social Studies:**
 - **II.2.LE.2** (Geographic Perspective: Describe the location, use, and importance of different kinds of resources and explain how they are created and the consequences of their use).
 - **II.2.LE.4** (Geographic Perspective: Explain how various people and cultures have adapted to and modified the environment).

Timeline: 1 week of class periods (40 – 50 minutes)

Class Structure: create a mini-book / whole class discussion

Assessment Strategy: EEK! Daily Assessment
Pre-Module Assessment Question #3
General Assessment Strategy #1
General Assessment Strategy #3

Lesson 5: 4th Grade

Mini Books: Maria Telkes and Solar Cooking

This lesson is a 10-page mini history lesson about Maria Telkes and the history of solar cooking.

Lesson Overview: Solar ovens are being used to cook food around the world today.

Lesson Concept: Our everyday actions impact others around the globe.

Supplies Needed:

- Student hand-out: Mari Telkes Mini Book
- Markers / Colored Pencils / Pencils

Teacher's Note: Directions for putting together the mini-book

- Make double sided copies of the pages (3 double sided pages total)
- Stack them on a table with the star symbol (•) in the right-hand lower corner of the page
- The top page will have an upside down image of Maria Telkes on the top of the page and 'The Sun Queen 1900 – 1996' with images on the bottom of the page
- The 2nd piece of paper will have 'Page Nine' on the top of the page and 'Page Two' on the bottom of the page
- The 3rd piece of paper will have 'Page Seven' with images on the top of the page and 'Page Four' with images on the bottom of the page
- Crease in the center (fold all pages in half)
- Staple along crease

Background Information:

Maria Telkes is considered the “inventor” of the modern solar oven. She actually did not invent the solar oven, but modified designs that had been previously used and tested creating a more efficient design. Her design is used throughout the world today. Primarily, though, she was a leading scientist in the study of renewable energy forms.

CLASS EXERCISE:

Have students create the mini-book. All support materials are provided in the Teacher Mini-Book Resource section following. There are a total of 10 lessons that can be divided throughout one week if desired.

TEACHER MINI-BOOK RESOURCE MATERIAL:

Title: Sun Queen/ 1900-1996

Page One: Dr. Maria Telkes was born in Hungary (1900) and went to college to be a scientist.

- Exercise:
 - Divide the map into: hemispheres, continents, and countries
 - Have students locate Hungary on the world map.
- Starter questions:
 - What hemisphere is Hungary in?
 - What continent is Hungary in?
 - What country is Hungary in?
 - How far is Hungary from the United States—take a guess

Teacher Background Information:

- Please use your class wall map to assist the students with this page
- Northern hemisphere; European continent; Eastern Europe
- The distance between Budapest, Hungary and Cleveland, Ohio (as the crow flies) is 4637 miles (7463 kilometers).
- Draw a line between the northern and southern hemisphere, color the continents different colors, outline Poland in a color, place a star on the general location of Hungary

Page Two: In 1925, Maria Telkes moved to the United States to be a scientist.

No image on this page, students will create image

- Exercise:
 - Have students draw the transportation method after discussing how she might have traveled to the U.S. in 1925. (Refer to the following support materials for discussion tips).
- Starter questions:
 - How do you think she traveled there?
 - How many miles do you think she traveled to reach the United States?

Teacher Background Information: Brief History of Transportation

Ships:

- When Maria Telkes traveled to the United States, the popular transportation modes of long distance travel were the ship and the locomotive.
- Ships are one of the oldest and most important means of transportation. The Egyptians invented sails by 3200 B.C. and used sailing vessels to explore their region.
- Throughout history different cultures used these vessels for transportation of goods and people and to explore the world. The shipping industry created vast trade routes between the continents and shaped cultures.
- In the early 1900s, steel hulls—rather than wood hulls—were developed and fuel oil replaced sailing (or was used in conjunction) as the main power source.

Trains:

- The first steam locomotive was invented by Richard Trevithick in 1804 in England.
- In 1830, the first locomotive passenger service ran in the U.S.
- In the 1930s and 1940s railroads switched from steam locomotives to diesel locomotives.

Cars:

- The word automobile was first used in France in the late 1880s. It comes from the Greek word *auto-*, meaning *self*, and the French word *mobile*, meaning *moving*.
- In the 1890s, the automobile was so new and so strange it was part of circus acts.
- In the 1800's cars were fueled by steam.
- By the 1920s, cars were fueled by gasoline.
- The automobile was not reliable for long distance travel until the 1940's.

Planes:

- In 1903 the Wright brothers made the first airplane flight in history.
- But it was not until the 1950s that the airplane was seen as a safe method of travel and non-stop passenger flights were available.

Page Three: As a scientist, Maria Telkes wanted to help people and the environment.

- Exercise:
Have students draw a picture of what they think a solar energy scientist might do.
- Starter questions:
 - Do you think solar energy is a renewable or non-renewable resource?
 - How would you describe (define) renewable energy?

Teacher Background Information: Renewable and Solar Energies

- There has been much debate over defining renewable energy because of the policy and regulation associated with promoting clean energy resources.
- In general, renewable energy does not include energy resources derived from fossil fuels, waste products from fossil fuels, or waste products from inorganic sources, according to The Texas Renewable Energy Industries Association.
- Solar energy is seen as having the possibility to be the key energy source in the future, since sunshine is the most predominant source throughout the globe.
- Renewable Energy Sources:
 - Solar Energy
 - Wind Power
 - Geothermal Energy
 - Hydroelectric

Page Four: Maria Telkes used the sun as an energy source in her experiments. She was called the “Sun Queen”.

- Exercise:
 - Have the students locate the Sun and Earth in the Solar System and circle both.
 - Have the students learn a Sun Fact(s) from the discussion about the Solar System. (Please see following material for discussion tips).
- Starter questions:
 - How far is the Sun away from the Earth?

Teacher Background Information: Solar System

The Sun:

- The sun is very large compared to the size of Earth.
- The sun's diameter (1,380,000 kilometers) is about 110 times Earth's diameter.
- If you thought of the sun as a large bowl, and Earth a piece of fruit, the sun could hold more than 1 million Earths.
- The sun is very hot. The surface temperature of the sun is about 5500°C (6000°K)

The Solar System:

- The earth is part of a larger system called the solar system.
- The solar system is comprised of 9 planets (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto), at least sixty-one moons (natural satellites), thousands of asteroids, millions of meteoroids, and many comets.
- All of these objects travel around the Sun at high speeds in paths called orbits.
- The sun is the central object around which other objects of the solar system revolve.
- Within the Solar System, the earth is the 3rd planet from the sun.
- A supersonic jet can fly from Paris to New York in about 3 1/2 hours. If a supersonic jet could fly through space at the same speed, it would take about 10 years to reach the sun. That is how far away the sun is from Earth.
- Even though the sun and the moon appear to be nearly the same size, the sun is 400 times further away from Earth.

Periods of Revolution

Planet **Period**

Mercury	88 Days
Venus	225 Days
Earth	365.25 Days
Mars	687 Days
Jupiter	12 Years
Saturn	29.5 Years
Uranus	84 Years
Neptune	165 Years
Pluto	248 Years

Page Five: Dr. Maria Telkes was a great inventor!

- Starter questions:
 - In the mid 1950's through the late 1960's, Maria Telkes was one of many people working on solar energy devices. But, she was one of the few women working in this field of science.
 - Who were some of Telkes' contemporaries and other influential women of this era?

Teacher Background Information

- Provide scenario of what was happening around the world in the late 1950s through late 1960's.
- Other 'famous' women of the time:
 - Mother Teresa (1910 – 1997)
Mother Teresa helped thousands of people and primarily worked with the poor of Calcutta, India. Among other prizes, she received the Nobel Peace Prize in 1979. She was born in Macedonia in 1910 and joined a community of nuns in India in 1931.
 - Frida Kahlo (1907 – 1954)
Frida Kahlo was a painter. Her work reflected the strong social, economic, and political ties she felt toward the cultural renewal of Mexico's native heritage. Kahlo's hauntingly personal paintings have influenced international recognition of Mexico's cultural heritage and Mexican painters.
 - Maya Angelou (b. 1928)
Maya Angelou is an author, poet, historian, songwriter, playwright, dancer, stage and screen producer, director, performer, singer, and civil rights activist. She is best known for her writing. Her work and presence have helped shape American society and push the boundaries of literary thought and humankind.
 - The Supremes
The Supremes are considered by many to be the most successful female vocal group in the nation. The women of the Supremes were role models for young women, especially African-American women, and helped reshape the sounds of music. They were first signed to Motown Records in Detroit, MI in the late 1950's. Their original name was the Primettes.
 - Rosa Parks (b. 1913)
Rosa Parks is considered the "mother" of the civil rights movement. Historians believe the civil rights movement began on December 1, 1955 the day Parks chose not to give up her seat to a white passenger. This stance began the bus boycotts that were used as demonstrations of race inequality in this country and led to the ending of segregation in the United States.
 - Marilyn Monroe (1926 – 1962)
Marilyn Monroe changed preconceived notions of women's bodies in society with her voluptuous curves and personified glamour and beauty. During her career, she made thirty films. She is inspirational to many and has become an American icon.

- Eleanor Roosevelt (1884 – 1962)
Eleanor Roosevelt transformed the role of the First Lady. She became First Lady when her husband, Franklin D. Roosevelt, was elected as president in 1933. During the presidency, she traveled around the world advocating human rights. She was influential and inspirational to many and expanded the expectations of women's roles in society.

Page Six: She cooked with sunshine!

- Exercise:
 - Have students arrange the images in historic order
- Starter Questions:
 - What do you think was the first item to be heated or cooked in a sun oven?
 - When do you think the first solar cooker was invented?

Teacher Background Information: A Quick Overview of Recorded Solar Oven (solar cooker) History

- Experimentation with making food in solar ovens began over 300 years ago.
- 1651 to 1708: Tschirnhausen, a German physicist, reportedly used a large lens to focus the sun's rays to boil water in a clay pot.
- 1767: Horace de Saussure, a Swiss scientist, makes wooden "hot boxes" to cook fruit. He also publishes a paper on solar cooking experiments.
- 1770s: French scientist, Ducarla, a contemporary of de Saussure's, improved on these primitive solar hot boxes by adding mirrors to reflect more light into the box and added more insulation. He was able to cook foods, including meat, in just one hour.
- 1877: French scientist, Mouchot, designed and built solar cookers for French soldiers in Africa. He baked bread in about 3 hours and even built a solar cooker that steamed vegetables.
- 1878: The magazine, *Scientific American*, published an article describing successful cooking of a meal of meat and potatoes for 7 people in Bombay, India.
- Sir John Herschel wrote the first, known, book on cooking with the sun, *Solar Energy and Its Industrial Applications*.
- 1884: Dr. Samuel P. Langley, an American scientist, made a large box cooker of wood and cooked meals with it while on top of Mt. Whitney near Pasadena, California.
- Early 1930s: French scientists renewed the country's interest in solar cooking, and many cookers were sent to French colonies in Africa.
- Early 1950s: Scientists in India designed and manufactured commercial solar ovens and reflector cookers.
- **Mid 1950s: Dr. Maria Telkes at New York University designed and demonstrated insulated solar ovens capable of reaching temperatures above 350° Fahrenheit.**
- 1955: Association of Applied Solar Energy (AFASE) held its first conference in Phoenix, Arizona. Many practical solar ovens and reflector cookers were demonstrated at this meeting and received wide publicity.
- Late 1950s: Solar cookers were introduced to Native American Indians living on reservations in the American Southwest.

- 1991: International Solar Energy Society held its annual meeting in Denver, Colorado. More than 1400 delegates from dozens of foreign countries attended the conference, which included sessions on solar cooker design, and demonstrations of these cookers in use.
- 1990s - present: Many organizations world-wide are bringing solar cooking to people in India, Haiti, South America, Central America, China, and throughout the African continent.

The above information is from *Cooking with the Sun*, Beth and Dan Halacy, Morning Sun Press, 1992–Morning Sun Press, P.O. Box 413, Lafayette, CA 94549, 925-932-1383–ISBN#0-9629069-2-1

Page Seven: Dr. Maria Telkes redesigned the solar oven to make it more effective.

- Exercise:
 - Engage students in a discussion about the two pictures of solar cookers.
- Starter Questions:
 - By looking at the picture below, which one do you think is Maria Telkes' design?
 - How do you think she improved the solar oven?

Teacher Background Information: The Basics on How a Solar Oven Works

- A solar oven is basically an insulated box with an aperture that has a transparent glass or plastic cover (glazing).
- Solar ovens use the “greenhouse effect” to cook food. Short wavelength solar radiation passes through the glazing, and strikes the interior sides of the oven and cooking pot.
- The interior sides of the oven can be either reflective or black.
- If the sides are reflective, the sunlight reflects onto the pot and heats it.
- If the sides are black, the sunlight is absorbed and then re-radiated at longer wavelengths heating the oven interior and cooking the food.
- The glazing also helps reduce heat loss.
- Solar ovens use both direct and indirect solar radiation—this allows them to operate better than concentrator cookers under slightly cloudy conditions.
- Placing an insulated cover over the aperture glazing helps to reduce heat loss and keep food hot if thick clouds block the sun for extended periods.
- Oven temperatures generally reach 400° to 450° F and are suitable for almost any kind of cooking except frying.
- **Solar Oven Designs and Telkes' Improvement:**
 - There are two major solar oven designs: one that uses multiple exterior reflectors surrounding the top opening *and* one that uses only one reflector.
 - The first (multiple reflectors) was developed by Dr. Maria Telkes and others. This was a significant contribution because the oven no longer needed to be tilted to adjust to the sun's changing angles throughout the day. The reflectors are set at a specific angle to focus additional solar radiation into the oven.
 - The single reflector design attaches the reflector to the oven with a hinge. This design requires adjusting the reflector usually every 30 minutes to re-orient the

sun's rays into the oven.

- The single reflector design usually reaches temperatures of 250° to 300° F. Consequently, this type of solar oven takes longer to reach maximum temperature and cooks food slower than a multiple-reflector solar oven.

(The above information discussing different types of solar is from the Office of Energy Efficiency and Renewable Energy, please see their website for further information www.eere.energy.gov)

Page Eight: She taught people all over the world how to cook with her solar oven.

- Exercise:
 - Have the students brainstorm what types of foods / meals might be cooked in a solar oven.
 - Have the students create a recipe to cook in a solar oven. Encourage them to create a recipe that they would enjoy eating. (ex. beans and rice, or a stew of vegetables and meat, etc.)
- Starter Questions:
 - What kind of foods do you believe would be best to cook in a solar oven / solar cooker?

Teacher Background Information: Overview of Foods Eaten Around the World

The best foods to cook in a solar oven are beans, rice, and breads. Foods that are simmered in order to cook them or 'one-pot' type of meals or stews are also very good choices for solar oven cooking. Breads and other cake-like desserts also cook very well in a solar oven.

Page Nine: Where geographically do you think the solar oven would work the best?

- Exercise:
 - Have students draw an image of the type of climate they believe would be a good choice for cooking foods in a solar cooker / solar oven. (The emphasis of this exercise is primarily two-fold: 1) to discuss countries where solar cookers are being used as a main source of cooking (our emphasis is India, Kenya, and Haiti) and 2) to discuss that solar cookers can be used anywhere in the world where the sun shines.
- Starter Questions:
 - What places around the world would be good because of their climates?
 - What types of food do you believe would people eat in these parts of the world?

Teacher Background Information: Countries to Focus On

India: At the end of 1993, 340,000 solar cookers were in use throughout India. The Indian government has sponsored an incentive program for communities and individuals to purchase and use solar cookers. This program includes: free distribution of solar cookers to schools, colleges, and universities; free training programs; reimbursement of purchasing fees if the solar cooker is used for one-year continuously; and, 50% reimbursement for repairs and maintenance to the solar cookers for up to 5 years when used continuously.

Cereal grains, primarily rice, provide approximately 50% to 69% of the average daily calories in the typical Indian diet. The average daily protein intake in India is less than 19%. (*Penguin Atlas of Food: Who Eats What, Where, and Why*, Millstone & Lang, ISBN # 0142002240)

Since the Indian government has been actively involved in promoting the use of solar cookers, large, dish-type, cookers are being used in villages as community ovens. This type of solar cooker can reach high enough temperatures to fry foods. But, the more common box-type solar cooker can be used to cook a variety of traditional foods such as purees of grains and legumes, and stews made from grains, legumes, vegetables, and meats. It should be noted, however, many of the traditional Indian foods require frying. Therefore, the individually used box cookers are not as successful without significant training in how to cook traditional foods.

(*Solar Cooker Review: India's Solar Cooking Program*, Dr. A.K. Singhai. Further information discussing India's solar cooking program can be found on the Solar Cooking Archive website www.solarcooking.org)

Kenya: Cereal grains cannot be grown in the tropics. Therefore, roots and tubers are an important staple food. Cassava, yams, cocoyam, taro, and sweet potato are all types of root vegetables. These vegetables can be stewed, simmered or boiled until soft and then mashed into paste similar to mashed potatoes. These types of vegetables provide 50% to 69% of the daily calories for the Kenyan people. These foods tend to be high in carbohydrates, so they are often referred to as 'starchy staples'. These starchy staples are also low in protein and need to be supplemented by nuts or malnutrition is likely to result. The average daily protein intake in Kenya is less than 19%. (*Penguin Atlas of Food: Who Eats What, Where, and Why*, Millstone & Lang, ISBN # 0142002240)

A stew made from rice, meat, potatoes and tomatoes takes about three hours to cook in a solar oven on a sunny day in Kenya. A pot of water takes about a half an hour to boil for tea. (Solar Cooking Archive, www.solarcooking.org)

Haiti:

Starchy tubers such as manioc and potatoes are typically eaten in Haiti as well as smoked fish, millet and plantains. The average daily calorie intake from animal protein is approximately 12% per person. Fruits, vegetables, and nuts make up approximately 20% – 30% of the average caloric intake per person and cereal grains average 30% - 40% of the total daily calories eaten.

Most of Haiti is now deforested and has become a desert compared to the once lush rainforests that populated much of the island country. Eighty-five percent of the Haitian population depends on traditional fuels, wood, charcoal, or dung, as their primary fuel source for cooking foods.

(*Penguin Atlas of Food: Who Eats What, Where, and Why*, Millstone & Lang, ISBN # 0142002240)

Page Ten: How do you think solar energy helps people? Do you think it is important to use solar energy? Why? Or Why not?

- Provide blank space to write down ideas

Teacher Background Information: Deforestation and Habitat Loss

- More than 2 billion people worldwide depend primarily on wood for their energy needs.
- Domestic cooking accounts for 60% of wood burning in developing nations and as much as 90% in some areas. . (Please see the article, *Introducing Solar Ovens to Rural Kenya*, Dr. Kammen from Solar Cooking Archive for a more detailed discussion of health hazards from cooking in Kenya, www.solarcooking.org/kammen93.htm)

One of the most diverse and important ecosystems on earth are forests. Non-humans and humans alike depend on these systems to provide habitat and resources. Trees are natural consumers of carbon dioxide (CO₂). CO₂ is one the greenhouse gases building in the atmosphere and the primary contributor to global warming. Destruction of trees not only removes these 'carbon sinks,' but burning trees for fuel pumps even more carbon dioxide into the atmosphere along with methane (another major greenhouse gas). (National Geographic Society, www.nationalgeographic.com/eye/deforestation/effect.html)

The following information on deforestation has been compiled by Zero Population Growth (www.zpg.org)

- Both tropical and temperate rainforests are rapidly disappearing because they are being logged and burned far faster than they are being replenished.
- One of the catastrophic consequences of continued deforestation is mass species extinction.
- The tropical rainforests are home to 50% to 70% of all species on the planet.
- An estimated 20 to 75 species become extinct every day due to rainforest destruction.
- By 2015, 6% to 14% of all species on the planet today are expected to be extinct.
- Since the roots of trees and smaller forest cover stabilize the soil, deforestation allows potentially severe local damage from rainfall including erosion, flooding and landslides.
- Globally, deforestation affects the world's climate. A broad uprising of air follows the rainforests around the equator, driven, in part, by heat absorbed by tropical forests. This massive uprising helps drive the circulation patterns of the entire global atmosphere. Tropical deforestation can disrupt this process, resulting in reduced rainfall and altered weather conditions over a large portion of the globe.
- An intact forest naturally removes carbon dioxide from the air and stores it through the process of photosynthesis. When trees are cut down, this carbon dioxide is released into the atmosphere.
- Tropical deforestation releases 1.5 billion tons of carbon dioxide every year—that's 19 % of the total global CO₂ emissions.

Reasons to Use Solar Cookers:

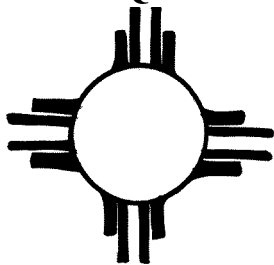
- Burning fossil fuels release a wide range of pollutants—primarily carbon dioxide and methane the leading greenhouse gases causing global warming. Solar cooking does not burn these fuels.
- Acute respiratory infections—caused by inhaling wood smoke—are becoming one of the leading killers in areas where wood burning is the primary source of fuel. In 1994, the World Health Organization (WHO) estimated that severe respiratory disorders kill more than 4 billion people a year.
- 1.8 billion people live in 40 countries with critically low levels of forest cover. Women often bear the burden of forest scarcity having to walk further for wood, carrying loads of firewood long distances, or suffering from a variety of ills associated with cooking where wood is scarce. (zpg.org)
- Using solar cookers reduces time, effort, and resources spent searching for wood or purchasing a fuel source. This could measurably affect quality of life.
- Solar cookers can have multiple purposes. They can cook and bake food, and purify biologically polluted water by pasteurization. Biologically polluted water causes many diseases and human misery killing millions of people annually.

(Resource: *Heaven's Flame: A Guide to Solar Cookers*, Joseph Radabaugh, 1998, ISBN# 0-9629588-2-4. This book is an excellent resource for building solar cookers (detailed instructions are provided) and general background on solar cooking. This book can be purchased by contacting: Home Power Publishing, P.O. Box 275, Ashland, OR 97520, 800-707-6585)

Maria Telkes 1900 - 1996



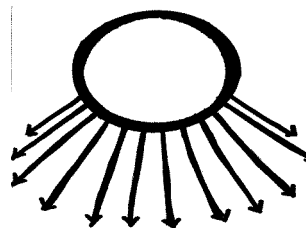
The Sun Queen 1900 - 1996



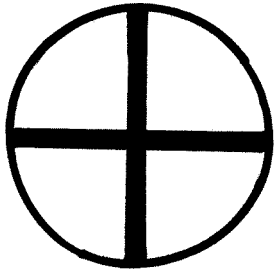
Zia Pueblo Sun Symbol



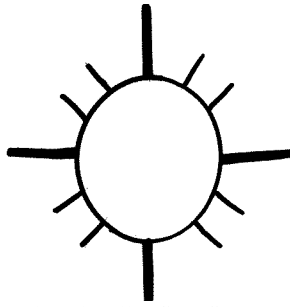
Ancient Celtic Spiral Sun



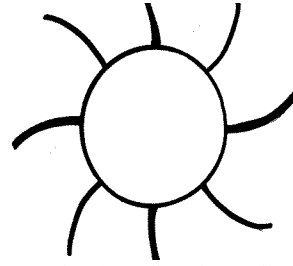
Aztec Rising Sun



Four Directions Sun



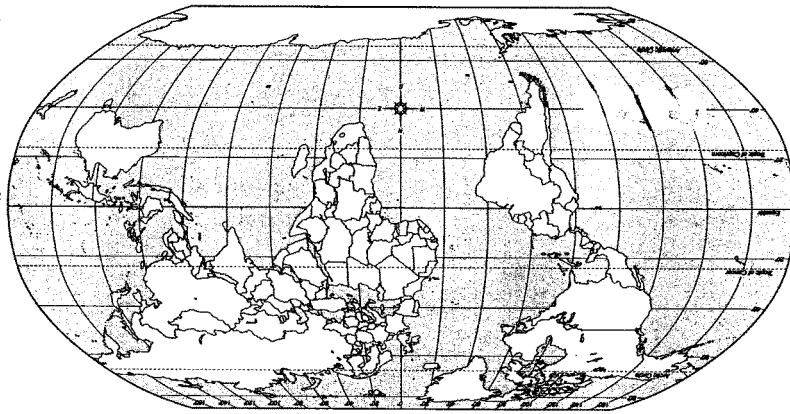
Huichol Tribe Sun Symbol



Ancient Sun from Crete

Page Ten: How do you think solar energy helps people? Why do you think it is important to use?

*



Page One: Dr. Maria Telkes was born in Hungary (1900) and went to college to be a scientist.

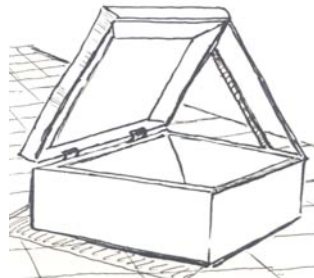
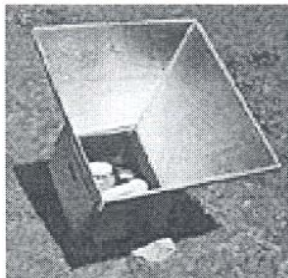
Page Nine: Where do you think the solar oven would work the best?

Page Two: In 1925, Maria Telkes moved to the United States to be a scientist.

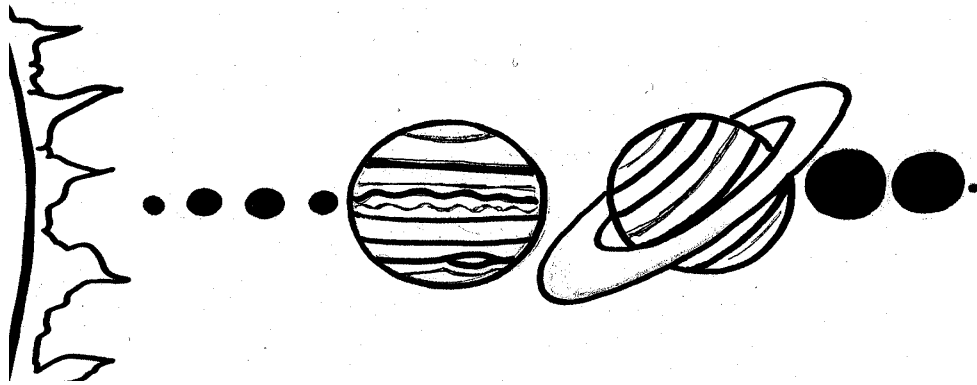
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Page Eight: She taught people all over the world how to cook with her solar oven.

Page Three: As a scientist, Maria Telkes wanted to help people and the environment.



Page Seven: Dr. Maria Telkes redesigned the solar oven to make it more effective.

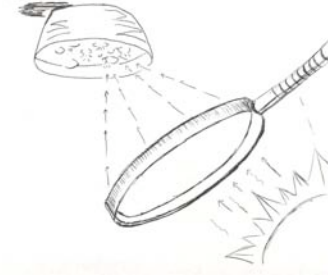
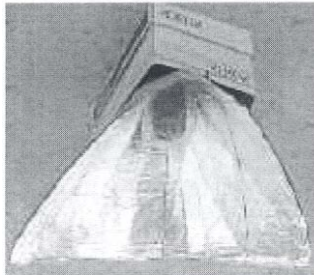
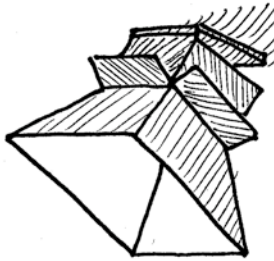


(not drawn to scale)

Page Four: Maria Telkes used the sun as an energy source in her experiments. She was called the “Sun Queen”.

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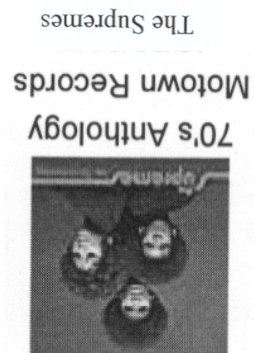
Page Six: She cooked with sunshine!



Mother Teresa

Maya Angelou

Maria Telkes



Rosa Parks



Eleanor Roosevelt



Lesson 6: 4th grade

Cooking Internationally: 3 Solar Oven Projects

Lesson Overview: Solar ovens are being used throughout the world.

Lesson Concept: Many people throughout the world do not have access to wood, electricity, or gas to cook food and heat water.

Materials:

- World map

Standards:

- **English:**
 - **VII.9.LE.1** (Depth of Understanding: Explore and reflect on universal themes and substantive issues from oral, visual, and written texts).
 - **VIII.10.LE.3** (Ideas in Action: Use oral, written, and visual texts to research how individuals have had an impact on people in their community and their nation).
- **Social Studies:**
 - **II.2.LE.2** (Geographic Perspective: Describe the location, use, and importance of different kinds of resources and explain how they are created and the consequences of their use).
 - **II.2.LE.4** Geographic Perspective: Explain how various people and cultures have adapted to and modified the environment).
 - **IV.1.LE.1** (Economic Perspective: Explain why people must face scarcity when making economic decisions).
 - **IV.1.LE.2** (Economic Perspective: Identify the opportunity costs in personal decision making situations).
 - **IV.2.LE.1** (Economic Perspective: Distinguish between natural resources, human capital, and capital equipment in the production of a good or service).

Timeline: 1 week of class periods (40 – 50 minutes)

Class Structure: whole class discussion

Assessment Strategy: EEK! Daily Assessment
General Assessment Strategy #2
General Assessment Strategy #3

Lesson 6: 4th Grade

Cooking Internationally: 3 Solar Oven Projects

This lesson is devoted to discussing 3 different solar oven projects underway in different parts of the world—Kenya, India, and Haiti.

Lesson Overview: Solar ovens are being used throughout the world.

Lesson Concept: Many people throughout the world do not have access to wood, electricity, or gas to cook food and heat water.

Supplies Needed:

- World map

Background Information:

There are many people throughout the world experimenting with and using solar ovens. Using solar ovens to cook food has many advantages. But, there are two significant elements to consider when deciding if using a solar cooker is appropriate:

- Climate—using solar cookers effectively requires a warm climate, or a warm day, with long sunny days (or a minimum of 4 hours of sun per day)
- Food preferences—some traditional foods may not cook well in a solar oven

CLASS EXERCISES:

I. Present and discuss the following three international solar cooking projects. Topics for discussion may include:

- Need for solar cooking (are the students aware of the needs)
- Different methods of cooking throughout the world

II. Discuss using solar ovens not only to cook food but to also purify biologically polluted water by pasteurization. Biologically polluted water causes many diseases in countries where people do not have access to safe drinking water sources.

World Awareness: What do you think?

1. What is the approximate world population today?
a) 5 million b) 3 billion c) 6 billion
2. How many people worldwide do not have access to safe drinking water?
a) 2.1 billion b) 90 million c) 1.5 billion
3. Of all the water on the planet, how much is available for human consumption?
a) 5% b) 3% c) less than 1%

questions compiled by Population Connection www.popconnect.org 1-800-767-1956
c, a, c

SOLAR OVEN PROJECT PROFILES: KENYA, INDIA, HAITI

E.E.K! Project for Sustainable Development 10/15/2006—Sustainable Futures Group 2006—sustainablefutures@hotmail.com

Kenya: Dr. Daniel Kammen



Image from Solar Cooking Review (www.solarcooking.org/newsletters)

Dr. Kammen, a professor at UC Berkeley, has been actively involved in introducing solar ovens to rural Kenyan communities. His projects have been successful mainly because he has adopted a deeply community-centered approach. Support for the solar oven project has been provided by different organizations throughout the years—Earthwatch, the University of Nairobi, the Kenyan National Academy of Sciences, the Ambassadors Development Agency of East Kenya, and the African Center for Technology Studies. The Solar Oven Project gained enough success to fund a dedicated staff member in Kenya who leads training seminars year-round with the assistance of community leaders who are also trained in building, cooking with, and teaching others about solar ovens.

After initially introducing a solar oven within a village by cooking a meal of ugali (a traditional staple meal of cornmeal and beans), the villagers help each other build their ovens and then cook a meal together using the solar ovens. In this way, using the solar ovens becomes a community event. These projects have a very high success rate for communities continuing to use the solar ovens even after the Solar Oven Workshop is completed.

As of 1993, Kammen's project had helped introduce more than 175 solar ovens in East Kenya that were being used daily to cook food. In the village of Zombe, 60 ovens were built for village use and the community decided to continue building and selling solar ovens as a "village industry".

The solar ovens that are built in Kenya are the design created by Maria Telkes in the 1950s. The ovens are constructed out of plywood, glass, and aluminum foil.

Below are a few of the main reasons how using renewable energy through solar cooking can make a huge impact on quality of life for rural Kenyans. (These views and statistics have been copied from Peter Tyson's article, "Solar Ovens Heat up in the Tropics". This article can be found at Technology Review, May-June 1994 v 97 n4, page 16(2). For further information on Dr. Kammen's Renewable Energy Projects, please see the Tyson article and articles published at www.solarcooking.org/kammen93.htm).

- Acute respiratory infection, caused by inhaling wood smoke, kills more children every year in Kenya than dysentery—a leading killer in developing countries.

- “Most rural Africans cook indoors by burning wood. Inside these smoky cooking huts, the pollution affect is the equivalent of smoking several packs of cagarettes a day. Acute respiratory infection, caused by inhaling wood smoke, kills more children every year in Kenya than dysentery—a leading killer in developing countries.” (Kammen, MIT Technology Alumni Association, 1994)
- The average Kenyan spends up to 40% of their income on fuel, 74% of which is devoted to cooking.

Kenya's Foods:

Cereal grains cannot be grown in the tropics. Therefore, roots and tubers are an important staple food. Cassava, yams, cocoyam, taro, and sweet potato are all types of root vegetables. These vegetables can be stewed, simmered or boiled until soft and then mashed into paste similar to mashed potatoes. *These types of vegetables provide 50% to 69% of the daily calories for the Kenyan people.* These foods tend to be high in carbohydrates, so they are often referred to as ‘starchy staples’. These starchy staples are also low in protein and need to be supplemented by nuts or malnutrition is likely to result. *The average daily protein intake in Kenya is less than 19%.* (Penguin Atlas of Food: Who Eats What, Where, and Why, Millstone & Lang, ISBN # 0142002240)

A stew made from rice, meat, potatoes and tomatoes takes about three hours to cook in a solar oven on a sunny day in Kenya. A pot of water takes about a half an hour to boil for tea. (Solar Cooking Archive, www.solarcooking.org)

Kenya's Water:

Water is scarce in Kenya. According to recent statistics from UNICEF, 47% of Kenyans do not have access to safe drinking water sources. When clean, safe drinking water is not available, illnesses increase especially in children and death rates rise.

India: A Government led Project



Image from Solar Cooking Review (www.solarcooking.org/newsletters)

India has a long history of solar cooking. In 1878, *Scientific American* published an article describing using a solar cooker. In Bombay, a meal of meat and vegetables was successfully cooked for seven people.

Since 1982, India's government has sponsored the development of using renewable energy for everyday uses. One of the main projects has been distributing box-type solar cookers across India. The government will pay 1/3 of the total cost of the solar cookers to individuals and communities who are interested in learning how to use them.

The Indian government has sponsored an incentive program for communities and individuals to purchase and use solar cookers. This program includes: free distribution of solar cookers to schools, colleges, and universities; free training programs; reimbursement of purchasing fees if the solar cooker is used for one-year continuously; and, 50% reimbursement for repairs and maintenance to the solar cookers for up to 5 years when used continuously.

In order to entice people to try out cooking with solar ovens, the Indian government created advertisements that portrayed solar cookers as other luxury items—radios, televisions, refrigerators, ovens.

At the end of 1993, 340,000 solar cookers were in use throughout India. Since the Indian government has been actively involved in promoting the use of solar cookers, large, dish-type, cookers are being used in villages as community ovens. This type of oven can reach high enough temperatures to fry foods. But, the more common box-type solar cooker can be used to cook a variety of traditional foods such as purees of grains and legumes, and stews made from grains, legumes, vegetables, and meats. It should be noted, however, many of the traditional Indian foods require frying. Therefore, the individually used box cookers are not as successful without significant training in how to cook traditional foods. (*Solar Cooker Review: India's Solar Cooking Program*, Dr. A.K. Singhai. Further information discussing India's solar cooking program can be found on the Solar Cooking Archive website www.solarcooking.org)

India's Foods:

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Potatoes and onions are staple vegetables. Other seasonal fruits—mangos, dates, lemons, melons, citrus, and coconuts—are often eaten as pickles or as sweet, salty, or spicy (or a combination of these flavors) condiment relish served with rice or lentils. Various kinds of greens—mustard, spinach, radish, fenugreek, and chickpea—are also eaten. In general, vegetable consumption is low in most Indian households. Other vegetables that are eaten, though not often, include cauliflower, okra, eggplant, many types of mushrooms, tomatoes, radishes, and cucumbers.

A traditional meal of rice, lentils, and vegetables will typically take 1 1/2 to 2 hours to cook in the solar cooker. Solar cookers are also used to dry fruits, roast nuts, and bake cakes.

India's Water:

Today, India has the second highest population (only China has more people) in the world. There are nearly 5 times more people living in India than the United States. In 1997, 19% of the total population did not have access to safe drinking water sources. Today, according to UNICEF, that figure has risen to 26% of the total population. Given the impacts of such population density, India is also on the verge of water stress. Compared to the United States, India has nearly one-half of the available water supply per person (as that of the average American).

Haiti: Dr. Ruth Dow



Image from Solar Cooking Review (www.solarcooking.org/newsletters)

Living in Michigan, today, is a solar cooking revolutionary. For the past five and a half years, Ruth Dow and her husband Charles have taught people about solar cooking throughout Latin America. They are volunteers with Alfalit International, Inc. an organization that has been teaching about nutrition, gardening, and solar cooking for the past 40 years.

While Ruth and Charles have worked in Peru, Venezuela, Bolivia, Costa Rica, Nicaragua, Panama, Guatemala, Mexico, and the Dominican Republic, their work in Haiti was especially significant. Most of Haiti is now deforested and has become a desert compared to the once lush rainforests that populated much of the country. Many people—85% of the Haitian population—living in rural villages have depended on traditional fuels, wood, charcoal, or dung, as their primary fuel source for cooking foods. Bringing solar cookers to villages in Haiti has created a new sense of independence for many communities though the Dows have found it is very difficult to change cooking practices and habits that have been in place for generations.

Haiti's Foods:

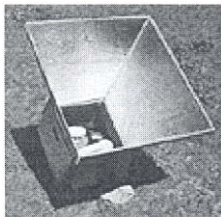
Starchy tubers such as manioc and potatoes are typically eaten in Haiti as well as smoked fish, millet and plantains. Families will often have a separate cooking kitchen—a dirt-floored shelter with a hole in the roof to let out the smoke—to keep the main house free from wood smoke and soot. This is often a situation that is good for everyone but the cook who will typically spend 3-4 hours a day in the smoke filled kitchen. Haiti has experienced continued drops in per-capita food production since 1981, primarily due to extreme economic and political hardship and ecosystem destruction.

Haiti's Water:

As of 1997, 69% of the total population did not have access to safe drinking water sources. Today, according to UNICEF, that figure has risen to 82% of the total population.

Solar Oven Designs–Box, Parabolic, and Combined

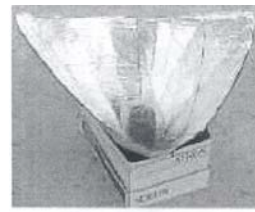
All images from Solar Cooking Review (www.solarcooking.org/newsletters)



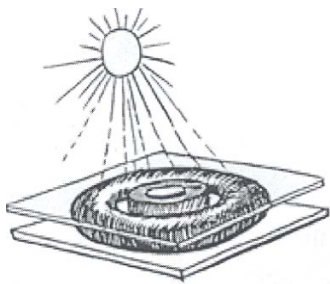
Heaven's Flame Box Cooker



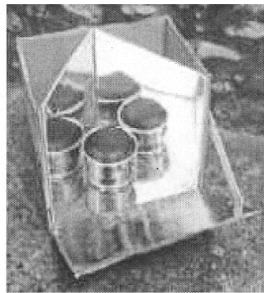
Minimum Box Cooker



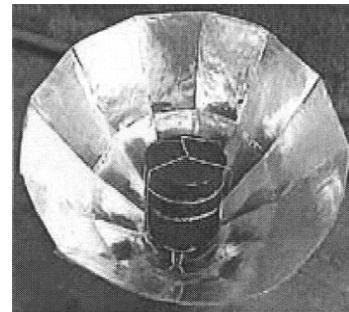
Solar Funnel Cooker



Tire Cooker



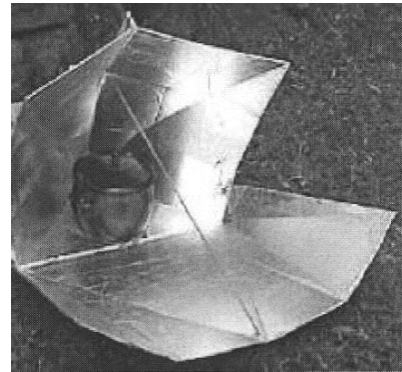
Reflective Open Box Cooker



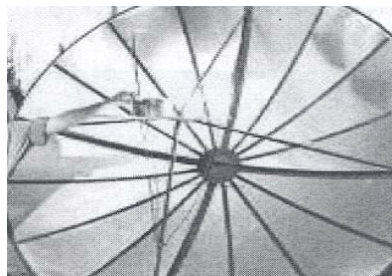
Pavarti 12-sided Cooker (Parabolic)



50 Gallon Drum Box Cooker



Pentagon Star Cooker (Parabolic / Box)



Satellite Dish Parabolic Cooker

Lesson 7: 4th grade

Solar Ovens: Experiments and Hypotheses

Lesson Overview: Testing and graphing results of two solar ovens' heating capacity.

Lesson Concept: Not all solar ovens work equally well.

Materials:

- Paper
- Pens / pencils / markers
- Solar cookers (already built)
- Student hand-out (or use teacher overhead): to discuss other types of solar cooker designs
- IR thermometer
- Oven thermometer (standard style)

Standards:

- **Mathematics:**
 - **III.1.LE.1** (Data Analysis and Statistics: Collect and explore data through counting, measuring and conducting surveys and experiments).
 - **III.1.LE.4** (Data Analysis and Statistics: Identify what data are needed to answer a particular question or solve a given problem, and design and implement strategies to obtain, organize and present those data).
 - **III.3.LE.2** (Data Analysis and Statistics: Conduct surveys, samplings and experiments to solve problems and answer questions of interest to them).

Timeline: up to 1 week of class periods (40 – 50 minutes) or 1-2 am / pm (half-day) class periods

Class Structure: whole class discussion / experiments

Assessment Strategy: EEK! Daily Assessment
General Assessment Strategy #2
General Assessment Strategy #3
General Assessment Strategy #4

Lesson 7: 4th Grade

Solar Ovens: Experiments and Hypotheses

In this lesson, students perform basic tests on the 3 different solar ovens that have been brought in to the classroom and then chart and graph all results.

Lesson Overview: Testing and graphing results of two solar ovens' heating capacity.

Lesson Concept: Not all solar ovens work equally well.

Supplies Needed:

- Paper
- Pens / pencils / markers
- Solar cookers (already built)
- Student hand-out (or use teacher overhead): to discuss other types of solar cooker designs
- IR thermometer
- Oven thermometer (standard style)

Teacher's Note:

An IR (infra-red) thermometer measures the surface temperature of an object. While the oven thermometer will measure the overall temperature of the heated area inside the solar oven.

- Have the students compare the temperature readings every hour with each thermometer as well as measure the rate that the water heats inside the oven.

CLASS EXERCISES:

Test #1: Measure the inside surface temperature with an IR thermometer

Test #2: Measure the inside temperature with an oven thermometer

Test #3: Measure the temperature of a glass of water with an oven thermometer

Graph Results:

- Have students measure temperatures of Tests #1, #2, and #3 over the class day (measure temperatures at least every hour).
- Create a time-data study by charting / graphing all results.

Lesson 8 & Lesson 9: 4th Grade
Building Solar Ovens: Small group collaboration

Lesson Overview: Building solar ovens for class use.

Lesson Concept: Learning how to work in effective and positive collaborative teams.

Materials: (please see specific plans)

- Minimal Solar Cooker plans
- Cardboard boxes
- Glue
- Plastic cooking bag
- UV tolerant black paint
- Aluminum foil

Standards:

- **Mathematics:**
 - **III.1.LE.1** (Data Analysis and Statistics: Collect and explore data through counting, measuring and conducting surveys and experiments).
 - **III.1.LE.4** (Data Analysis and Statistics: Identify what data are needed to answer a particular question or solve a given problem, and design and implement strategies to obtain, organize and present those data).
 - **III.3.LE.2** (Data Analysis and Statistics: Conduct surveys, samplings and experiments to solve problems and answer questions of interest to them).

Timeline: up to 1 week of class periods (40 – 50 minutes) or 1-2 am / pm (half-day) class periods

Class Structure: small groups / collaboration

Assessment Strategy: EEK! Daily Assessment
General Assessment Strategy #3
General Assessment Strategy #4

Lesson 8 & Lesson 9: 4th Grade

Building Solar Ovens: Small group collaboration

Lesson Overview: Building solar ovens (the Minimal Solar Cooker) for class use.
Lesson Concept: Learning how to work in effective and positive collaborative teams.

Supplies Needed: (please see specific plans)

- Minimal Solar Cooker plans
- Cardboard boxes
- Glue
- Plastic cooking bag
- UV tolerant black paint
- Aluminum foil

BACKGROUND MATERIAL

Building time: 3 hours

The following plans can be found at the website: solarcooking.org/minimum.htm

For more information regarding this solar cooker or any other solar oven questions, contact:

Solar Cookers International

1919 21st St. #101

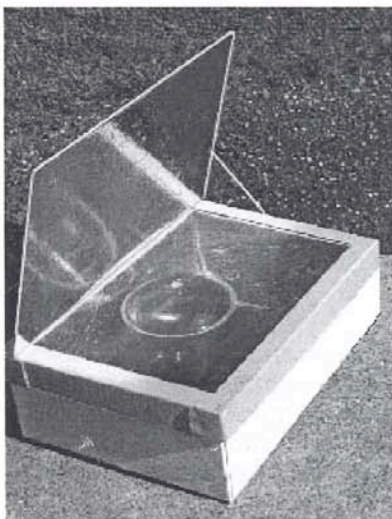
Sacramento, CA 95814

info@solarcookers.org

The following document is published on Solar Cooking Archive.

Lesson:

- Build two styles of Minimal Solar Cooker:
 - one with a reflective interior (aluminum foil covering)
 - one with an absorptive interior (painted flat black) *Note: There are specific paints that are specifically formulated for high temperatures. The maximum temperature of the Minimum Solar Cooker will be in the range of 400° Fahrenheit. Before painting the interior of the solar cooker, please check the paint specifications.*



The "Minimum" Solar Box Cooker

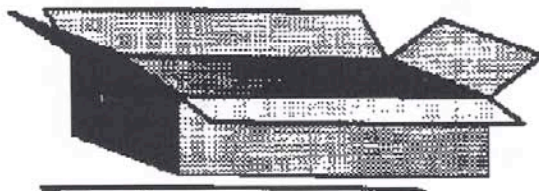
A great solar oven you can build quickly from two cardboard boxes

Experiments in Seattle and Arizona have proven that solar box cookers can be built more simply than even the simple method we have been using. These discoveries have paved the way for a simpler construction method that allows a cooker to be built in a few hours for very little money.

When we designed this cooker, we named it the "Minimum Solar Box Cooker" because, at the time, it represented the simplest design we could devise. What we didn't communicate with that name was that this is a full-power cooker that works very well, and is in no way "minimum" as far as capabilities.

What You Will Need

- Two cardboard boxes. We would suggest that you use an inner box that is at least 15" x 15" (38cm x 38cm), but bigger is better. The outer box should be larger all around, but it doesn't matter how much bigger, as long as there is a half inch (1.5cm) or more of an airspace between the two boxes. Also note that the distance between the two boxes does not have to be equal all the way around. Also, keep in mind that it is very easy to adjust the size of a cardboard box by cutting and gluing it.
- One sheet of cardboard to make the lid. This piece must be approximately 2" - 3" (4 - 8cm) larger all the way around than the top of the finished cooker.
- One small roll of aluminum foil.
- One can of flat-black spray paint (says on can "non-toxic when dry") or one small jar of black tempera paint. Some people have reported making their own paint out of soot mixed with wheat paste.
- At least 8 ounces of white glue or wheat paste.
- One Reynolds Oven Cooking Bag®. These are available in almost all supermarkets in the U.S. and they can be mail-ordered from [Solar Cookers International](http://solarcooking.org). They are rated for 400° F (204.4° C) so they are perfect for solar cooking. They are not UV-resistant; thus they will become more brittle and opaque over time and may need to be replaced periodically. A sheet of glass can also be used, but this is more expensive and fragile, and doesn't offer that much better cooking except on windy days.



Building the Base

Fold the top flaps closed on the outer box and set the inner box on top and trace a line around it onto the top of the outer box. Remove the inner box and cut along this line to form a hole in the top of the

outer box (Figure 1).

Decide how deep you want your oven to be (about 1" or 2.5cm bigger than your largest pot and at least 1" shorter than the outer box) and slit the corners of the inner box with a knife down to that height. Fold each side down forming extended flaps (Figure 2). Folding is smoother if you first draw a firm line from the end of one cut to the other where the folds are to go.

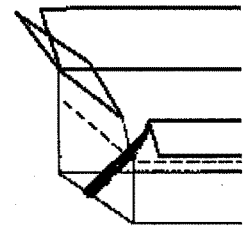


Figure 2

Glue aluminum foil to the inside of both boxes and also to the inside of the remaining top flaps of the outer box. Don't waste your time being neat on the outer box, since it will never be seen, nor will it experience any wear. The inner box will be visible even after assembly, so if it matters to you, you might want to take more time here. Glue the top flaps closed on the outer box.

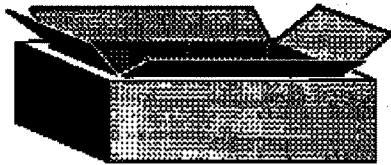


Figure 3

Place some wads of crumpled newspaper into the outer box so that when you set the inner box down inside the hole in the outer box, the flaps on the inner box just touch the top of the outer box (Figure 3). Glue these flaps onto the top of the outer box. Trim the excess flap length to be even with the perimeter of the outer box.

Finally, to make the drip pan, cut a piece of cardboard, the same size as the bottom of the interior of the oven and apply foil to one side. Paint this foiled side black and allow it to dry. Put this in the oven (black side up) and place your pots on it when cooking. The base is now finished.

Building the Removable Lid

Take the large sheet of cardboard and lay it on top of the base. Trace its outline and then cut and fold down the edges to form a lip of about 3" (7.5cm). Fold the corner flaps around and glue to the side lid flaps. (Figure 4). Orient the corrugations so that they go from left to right as you face the oven so that later the prop may be inserted into the corrugations (Figure 6). One trick you can use to make the lid fit well is to lay the pencil or pen against the side of the box when marking (Figure 5). Don't glue this lid to the box; you'll need to remove it to move pots in and out of the oven.

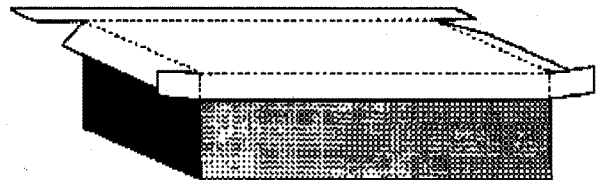
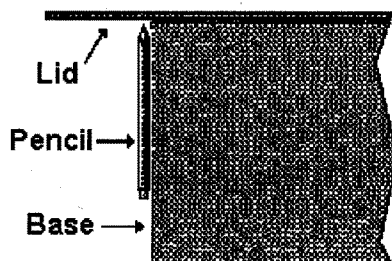


Figure 4



To make the reflector flap, draw a line on the lid, forming a rectangle the same size as the oven opening. Cut around three sides and fold the resulting flap up forming the reflector (Figure 6). Foil this flap on the inside.

To make a prop bend a 12" (30cm) piece of hanger wire as indicated in Figure 6. This can then be inserted into the corrugations as shown.

Next, turn the lid upside-down and glue the oven bag (or other glazing material) in place. We have had great success using the turkey size oven bag (19" x 23 1/2", 47.5cm x 58.5cm) applied as is, i.e., without opening it up. This makes a double layer of plastic. The two layers tend to separate from each other to form an airspace as the oven cooks. When using this method, it is important to also glue the bag closed on its open end. This stops water vapor from entering the bag and condensing. Alternately you can cut any size oven bag open to form a flat sheet large enough to cover the oven opening.

Improving Efficiency

The oven you have built should cook fine during most of the solar season. If you would like to improve the efficiency to be able to cook on more marginal days, you can modify your oven in any or all of the following ways:

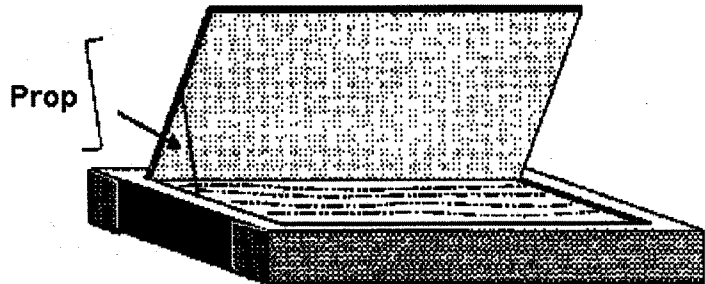


Figure 6

- Make pieces of foiled cardboard the same size as the oven sides and place these in the wall spaces.
- Make a new reflector the size of the entire lid (see photo).
- Make the drip pan using sheet metal, such as aluminum flashing. Paint this black and elevate this off the bottom of the oven slightly with small cardboard strips.

Here are some good documents to read to learn more about solar cooking:

- [Solar Cooking Frequently-Asked Questions \(FAQ\)](#)
- [Developing an Intuitive Feel for the Dynamics of Solar Cooking](#)
- [Principles of Solar Box Cooker Design](#)
- [Solar Cooking Hints](#)
- [Three Reasons Solar Cooking Deserves New Attention](#)
- [Solar Cookbooks](#)

For more information contact:

[Solar Cookers International](#)
1919 21st Street, #101
Sacramento, California 95814

info@solarcookers.org

This document is published on Solar Cooking Archive at <http://solarcooking.org/minimum.htm>

Lesson10: 4th Grade
Building Solar Ovens: Small group collaboration

Lesson Overview: It is important to become familiar with different cultures than our own. One great way to be introduced to another culture is through taste—eating different foods.

Lesson Concept: Solar ovens can be used successfully to cook different types of food.

Materials:

- Tin cans for cooking bread—either large juice tins (64 oz.) or small soup tins
- Pans for cooking stews—glass Pyrex casserole dishes are a good choice
- Wooden spoons for stirring (if necessary)
- Recipes
- Foods: peas, potatoes, canned tomatoes, sweet potatoes, carrots, bouillon, urad dal, rice (or any other vegetables for making soup) and spices

Standards:

- **Science:**
 - **II.1.EE.4** (Reflect on the Nature, Adequacy, and Connections Across Scientific Knowledge: Develop an awareness of and sensitivity to the natural world).

Timeline: up to 1 week of class periods (40 – 50 minutes) or 1-2 am / pm (half-day) class periods

Class Structure: small groups / collaboration

Assessment Strategy: EEK! Daily Assessment
Post-Module Assessment Questions #1, #2, #3

Lesson 10: 4th Grade

Cooking with Solar Ovens

Students will cook foods in their Minimal Solar Cookers today (or the next sunny day).

Lesson Overview: It is important to become familiar with different cultures than our own. One great way to be introduced to another culture is through taste—eating different foods.

Lesson Concept: Solar ovens can be used successfully to cook different types of food.

Supplies Needed:

- Tin cans for cooking bread—either large juice tins (64 oz.) or small soup tins
- Pans for cooking stews—glass Pyrex casserole dishes are a good choice
- Wooden spoons for stirring (if necessary)
- Recipes
- Foods: peas, potatoes, canned tomatoes, sweet potatoes, carrots, bouillon, urad dal, rice (or any other vegetables for making soup) and spices

Background Information:

It is important to stress that the solar ovens that the students tested in the previous lessons and the solar ovens that the students have made are *solar ovens that are used in different countries around the world*. **Solar ovens are used to cook food to feed people; they are not novelty items.**

The recipes included within this lesson were chosen for the following reasons:

- They represent a few of the basic, staple dishes from the countries included in the international solar oven projects lessons.
- The foods are available at the local grocery (Meijer's in Michigan).
- The dishes are one-pot dishes that can be easily cooked in the solar ovens.
- The dishes can be prepared by the students (all prep).
- The ingredients total under \$5 per dish.

Directions and Information for Lesson 10:

- We hope that you will choose one of the recipes provided or another soup or stew that would constitute a meal for a family and not cook hotdogs or bake potatoes in the solar ovens.
- Students may choose a dish from one of the 3 highlighted countries—Kenya, India, Haiti—create a recipe of their own, or cook breads. We have provided a few recipes below for various meal ideas that will cook well in the solar oven. Essentially, brothy soups, soft legumes (urad dal, yellow split peas, lentils) and rice are good choices.

- Legume and rice to water cooking ratio: generally 1:2 ratio (1 cup rice/legume to 2 cups water)
- Tin cans and Pyrex dishes are good cooking vessels for cooking stews.
- Tin cans are good cooking vessels for cooking breads.
- Smaller batches are generally more successful than larger: a meal for 4 – 6 people.

RECIPES

Rice Dishes

A Bit About Rice: Rice is an incredibly important staple around the world. Many different cultures eat rice daily and with vastly different foods. There are also many different kinds of rice, each having its own distinctive texture, flavor, and scent when cooked. A few different kinds of rice are:

- Sushi rice (Japanese)—short-grain, plump rice that is slightly sticky when cooked. After this rice is cooked, it can be formed into a ball with slightly moistened hands.
- Risotto rice (Italian)—round, medium-grain rice used for cooking with broths in many Italian dishes. It is a very starchy rice.
- Sweet (glutinous) rice (East Asia: Thailand, Laos, Cambodia, Vietnam)—opaque, white, short-grain rice used for everyday and making desserts. When cooked, this rice has a very creamy texture.
- Rice noodles (Asia)—noodles made from rice flour and water.
- White basmati rice (India)—Aromatic, long-grain rice grown historically in the foothills of the Himalayas where the sun and snow-fed rivers provide just the right nourishment. In Hindi, the name *basmati*—means “one with a good smell”. Aromatic rice, as basmati, has been prized through history. Basmati rice is unique in its appearance. The grain is slim and curves slightly upward. Once cooked, the entire grain elongates to 3 times its original (uncooked) length.

PLAIN BASMATI RICE (INDIA)

1 cup basmati rice

2 cups water

Mix together in dish and place in solar oven.

Depending on the weather, the rice should cook in approximately 1 hour and 15 minutes.

The rice is cooked when all of the water has been absorbed.

After the rice begins boiling, you may cover the cooking vessel with a lid.

The best temperature for cooking rice in the solar oven—300° F.
BASMATI RICE WITH COCONUT (INDIA)

1 cup basmati rice
1 cup water
1 cup canned coconut milk
dash of salt (optional)
1/4 c shred coconut (optional)

This rice is a slightly sweetened version of the previous recipe and could serve as a dessert.

Mix all of the ingredients together in dish and place in the solar oven.
Depending on the weather, the rice should cook in approximately 1 hour and 15 minutes.
The rice is cooked when all the water has been absorbed.
After the rice begins boiling, you may cover the cooking vessel with a lid.
The best temperature for cooking rice in the solar oven—300° F.

SPLIT URAD BEANS (URAD DAL) (INDIA)

1 cup urad dal
4 cups of water
1/2 teaspoon cumin
3/4 teaspoon salt

This is a staple dish of India—plain, lightly spiced beans. After the dish is cooked, it has a creamy consistency (almost like porridge) and delicate flavor. Add more salt if necessary. Also, fresh lemon can be squeezed on top of the urad dal after it has been cooked for added flavor.

Mix all of the ingredients together a dish and place in solar oven.
Depending on the weather, the urad dal should cook in approximately 4 hours.
The urad dal is cooked when most of the water has been absorbed and you have a creamy, white porridge.
After the urad dal begins boiling, you may cover the cooking vessel with a lid.
The best temperature for cooking urad dal in the solar oven—300°F to 350°F.

<p>Urad dal is cooked throughout India though considered a staple food in the area of Punjab. Urad beans have a dull black outer hull, but once the hull is removed the bean inside is a</p>
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creamy yellow color. Urad beans are used in a variety of meals from soups and stews to dumplings and *poppadums*—a light crisp cracker bread.

VEGETABLE STEW (AFRICA / HAITI)

2 sweet potatoes
3 to 4 cups of water or bouillon broth (mix bouillon cubes in water to taste)
1 potato
3 large carrots (optional)
1 large can diced tomatoes
pepper to taste
2 cloves of garlic—finely chopped
fresh herbs—finely chopped

Cut the sweet potatoes and the potato into small cubes.

Cut the carrots into thin slices.

Combine all of the ingredients and pour them into the cooking vessel.

Cook for 1 – 2 hours depending on the weather. You may want to cook the stew in an uncovered dish if you are cooking during a very sunny day. But, make sure the stew does not boil over.

The stew is done when the potatoes are soft. Serve with fresh herbs on top or cook the herbs into the stew for added flavor.

MILLET (INDIA, AFRICA, HAITI)

1 cup millet
1/2 teaspoon salt (optional)
1 tablespoon vegetable oil (optional)
2 cups water

Heat the water in solar oven until hot to the touch.

Add the millet and cook for 1 – 2 hours depending on the weather.

Millet is cooked when it has absorbed all the water. Fluff the millet with a fork after you have removed the dish from the solar oven.

Millet is believed to have been eaten by humans throughout Africa, Asia and southern Europe more than four thousand years ago. Millet is a tiny round grain that is very high in protein, rich in magnesium, and easy to digest. It is commonly roasted in a skillet over a hot flame before cooking in water. When cooking in a solar oven, though, this option is more difficult.

CORN BREAD (AFRICA, HAITI)

1 cup yellow cornmeal
3/4 cup flour
1/3 cup sugar
3 teaspoons baking powder
3/4 teaspoon salt
1 cup milk or soy milk or water
1 egg
2 tablespoons oil

In a large mixing bowl, mix together the cornmeal, flour, sugar, baking powder, and salt.
In another bowl mix together the milk (soy milk, water), egg, and oil.
Combine all of the ingredients until just blended.
Pour into a large tin or multiple small tins.
Bake until an inserted skewer or toothpick comes out clean.
Depending on the weather, a small tin should take 1 hour and a large tin 1 – 2 hours.

While corn may historically belong to the Americas, it is eaten throughout the world and can be found in Eastern Indonesian, African, Caribbean, and Indian recipes. Corn is cooked in a variety of ways throughout the world from soft breads—*polenta*—in Italy, to porridges—*mielie meel*—in Africa, to flatbreads in India, *tortillas* in the Americas, and corn bread throughout the United States.